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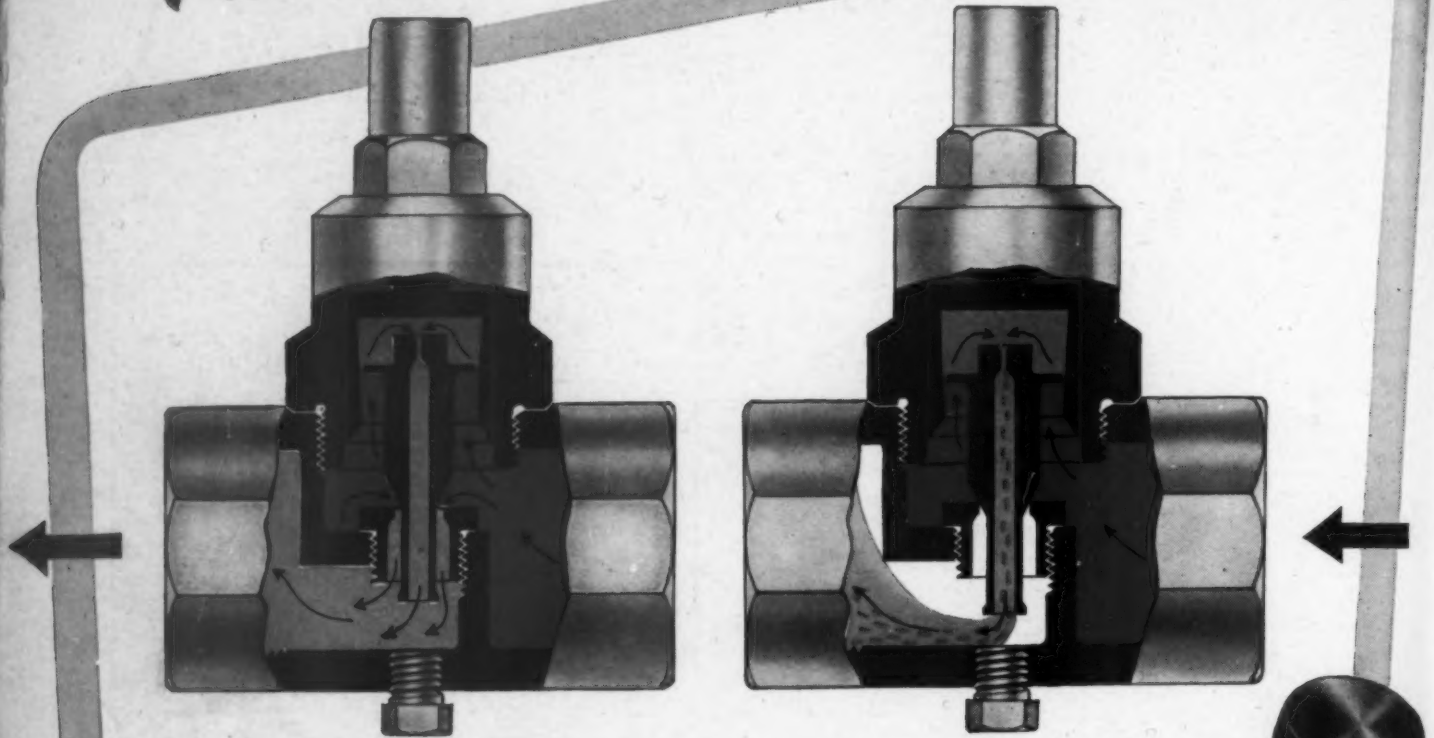

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VOLUME 26, NO. 6 JUNE, 1947

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

J. Kent Ridley

1890-1947

AS WAS his practice, shortly before 5 o'clock he gave each piece of copy careful inspection before sorting into a stack to be taken to the printing plant. The pages, still in need of reading, went back into his desk, which was in proper order before he left the office. Downstairs he stopped to chat with members of the night plant staff and to learn the progress of copy already going into type. Several fellow workers had places in his car by the time he reached it, for it was his practice to give them lifts as his course crossed bus lines en route to his home.

An hour and a half later came the message that Kent Ridley was dead. He had taken two or three steps up a ladder when a stroke hit with instantaneous consequence. So passed the man, who for more than 20 years as managing editor produced each issue of PETROLEUM REFINER. Other than advertising pages, each word that got into the publication passed his careful scrutiny. Even the advertising pages drew his painstaking attention as he arranged them so as to get full economy of the mechanism of the presses.

He came to editing by way of the printing shop, his first newspaper venture having been a weekly newspaper in Kirbyville, Texas, where he was printer as well as editor and publisher. After a few years in one of the larger printing establishments, reporting drew him away from type setting. From reporting he came to the Gulf Publishing Company, where his knowledge of printing found immediate appreciation in his ability to handle copy. He would have been 57 years old in June.

This expression of his loss in his profession seems trivial when compared with what his family has lost. He leaves a widow, a son, Kent Ridley, Jr., and two grandsons. Jim, the elder, has tasted the flavor of a Christmas in the Ridley home and he knows that the services in the Episcopal church in Houston May 14, 1947, removed something of great value from his life. Joe, the younger grandson, may be fortunate in that he is too young to realize what he has lost.

Kent Ridley would object to this effort at eulogy. Somehow, it seems fitting to set down a few notations of appreciation before the final page is turned. He was a man who bore no malice and held no envy. What others had properly earned he approved heartily just as he found delight in his own possessions. He was a gentleman and a thorough workman.

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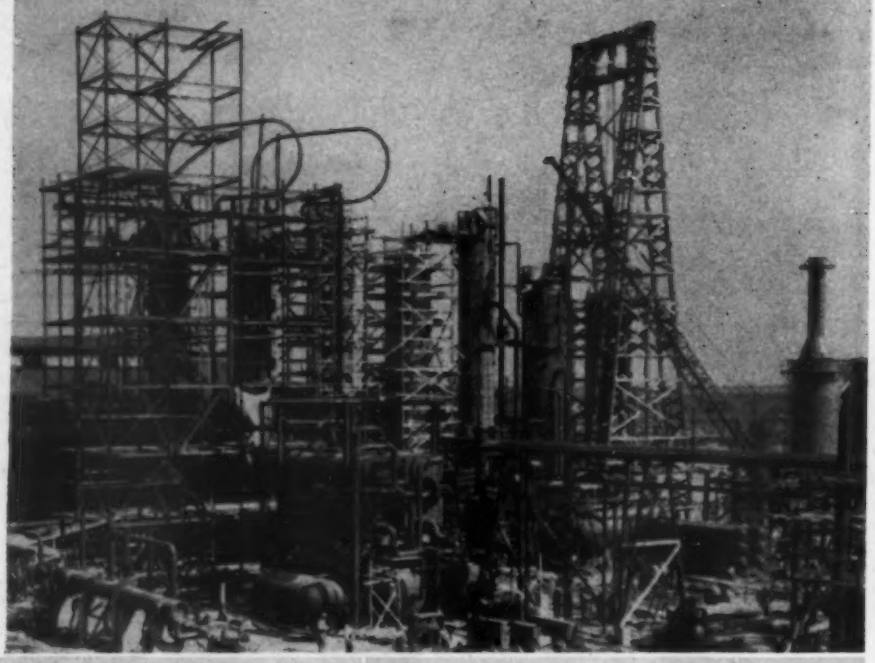

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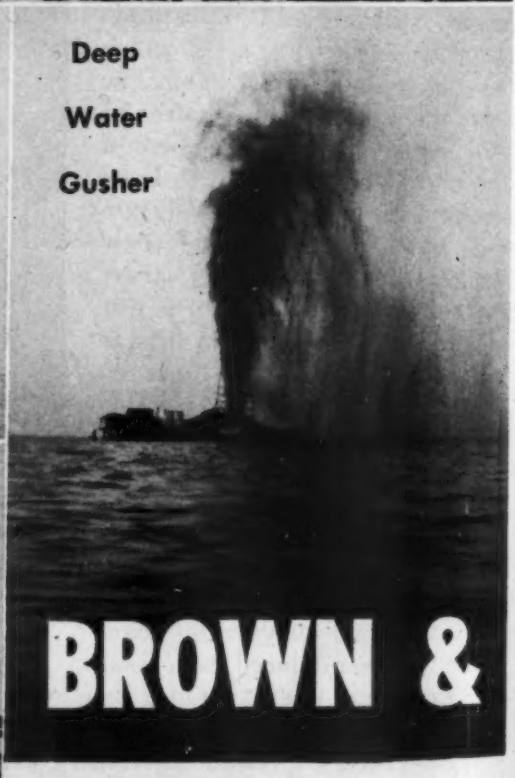

Oil Well Foundation in Gulf of Mexico

BROWN & ROOT, Inc.

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IT SEEMS obvious that some policies of plant operation should be left to executive decisions. For instance, the matter of the number of men who are to operate a new unit. There have been several delays in getting units on stream, even during the war, because union leaders demanded that they determine the extent of the operating staff.

Affairs of Management

This implies that men in an office are not competent to select the staff for a unit. This is so far from true, that union leaders had better look at their demands with a critical eye. Refining units are designed by men who know plant operation.

That the men on the job should confer with plant executives as to the number of workmen and other matters as a unit goes into production is admitted. But for a set of men to square off and fix the number of employees for a new and untried unit is preposterous.

AS A MEANS of getting goods moving so human beings can have food, clothing and other necessities, The American Roumanian Trading and Development Corporation stands out as something concrete. Ten corporations, among them Standard Oil Export Company, have formed the corporation as a nonprofit organization of $1,000,000 capital.

One Way

The announcement gave this concise explanation of what will be attempted:

"The new company will open an important trade channel between the two countries in addition to those already existing. By this development, Roumania's purchasing power abroad will be increased and aid given to raising the standard of living within the country."

Along with doing that the member companies will be protecting investments. Proper authorities of the two countries have been informed.

KEEPING pace with its prospect in consumption will tax the full resources of the petroleum industry as they were taxed during the war period. Here is a picture offered by leading economists: that consumption of oil in the United States will increase by 500,000 barrels daily by 1951; that it will increase to around 7,000,000 barrels daily by 1970.

Mounting Oil Use

In addition to increase in amount of oil processed, there is a demand for improvement in products indicated by the fact that half the motor fuel now sold is premium grade, while in 1941 less than 20 percent was of that grade. There is a demand for improved lubricants, for specification furnace oils, improved Diesel fuels and a demand for chemicals from petroleum.

Only more refining units can provide for processing more oil and for improving the quality of finished merchandise. It is a frantic building program now in prospect and it will tax the resources of steel manufacturers, fabricators and construction organizations.

Already several projects have been postponed because of the shortage of materials. Others are being pushed despite delays, excessive costs and substitutions. In these instances additional capacity is so desperately needed that management has elected to build despite handicaps.

SINCE the Anglo-American oil agreement has been re-written to restrict its scope and provide only for a dictum that the oil resources of the world be available to all nations and that oil should be produced in an "efficient and orderly manner," the question arises as to its value. Certainly no one would take the position that nations of good behavior are not entitled to oil. Likewise, where is the man, the committee or the nation in disagreement with the proposition that oil be efficiently produced.

Of What Value?

If that is all the agreement means, why have it? This is not to accept the proposition that the treaty provides only for that. Somehow, it is not easy to ignore that the first writing of the treaty provided for more than its conferees anticipated. Once the directors of the American Petroleum Institute approved it. The next year some critics had been at work on its wording and the API passed another resolution, still approving, but noting that the approval was conditional, that the agreement have no influence on domestic affairs in petroleum.

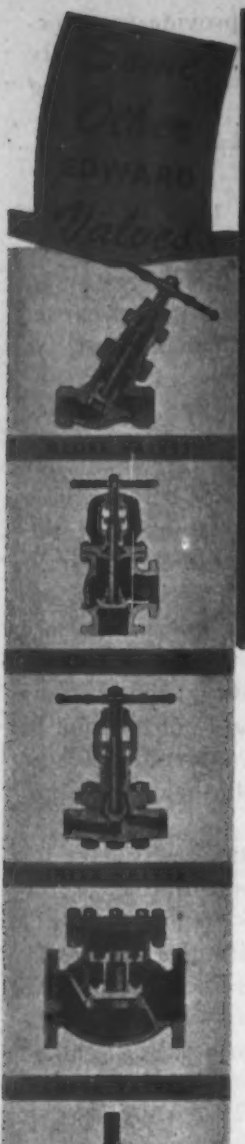
It would seem that the movement of oil from nation to nation could be better assured if trade on simple terms could be restored, a job much bigger than the petroleum industry.

IN HIS remarks to employes of the Toledo refining plant last month, Robert G. Dunlop, newly elected president of Sun Oil Company, put it in these words:

"Across the board salary and wage increases are possible only when the productivity per worker is increased."

That Simple

The proposition is that simple, still it is not understood. Furthermore lack of understanding is not restricted to those who are on the front line in production. Often the worker is criticized for demanding that a new machine not be installed, since it will throw men out of work. But the executive is as short-sighted when he declines to alter all or part of a plant, when there is evidence that something new will turn out merchandise at lower cost.



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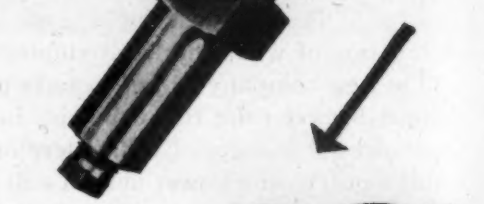

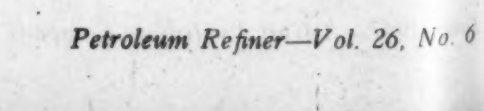

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EAST CHICAGO, INDIANA

Corrosion Studies

FOR THE PETROLEUM REFINING INDUSTRY

PART 1.

The Economic Aspects of Corrosion.

F. A. ROHRMAN
Head, Department of Chemical Engineering,
Kansas State College
Manhattan, Kansas

IN THIS first section of a three-part story, the author deals with the economic aspects of corrosion and with basic corrosion theory. In the second and third parts of the work, which will appear in early issues, factors affecting corrosion will be further discussed, as will corrosion testing, and corrosion prevention. The very serious economic losses occasioned in processing units and petroleum handling and storage facilities, by corrosion, are well known to operating engineers and maintenance men. The total is greater than the actual costs of material and replacement, as other factors, such as loss of time and products, product contamination, and damages incurred by equipment failure, may far exceed specific corrosion losses. Routine maintenance, inspection and replacement, has long been the conventional answer to corrosion difficulties, while other effective methods such as the use of more resistant construction materials, water treatment, counter-electrolytic protection, and others, have usually been reserved for the difficult cases. In some degree, this is the best procedure, as the problem is primarily an economic one, with the lowest overall cost the desirable result. Great progress has been made in recent years in combatting corrosion, with several methods demonstrating definite value in refinery applications, and the wide interest in this work has occasioned many inquiries to Petroleum Refiner. The problems generally are far too complex to permit the application of "standard" solutions, and it is believed that this present work will be of real value to plant men in providing basic knowledge of corrosion factors, a necessary prerequisite for an effective corrosion-cost-reduction program. Dr. Rohrman has handled a complex subject here in a manner readily intelligible to the layman, and at the same time has preserved accuracy of theory and completeness of explanation.

THERE are many references to the costs of corrosion in the chemical and allied industries. Some authorities would place this cost at an annual figure of two or three billion dollars, others at a yearly replacement of one third the steel and iron produced, and others at five to fifteen percent of the costs of finished products. These estimates actually may be found to underrate the over-all charges of corrosion in many industries. In order to understand the potential effects of costs it is necessary to visualize the many factors that contribute to the final costs of corrosion. These factors may be tabulated as:

1. Costs of equipment and plant replacement.
2. Loss of time or production schedules by shutdowns.
3. Costs of inspections and maintenance.
4. Costs of protective means other than by maintenance.
5. Loss of product or conveyed material.
6. Product contamination.
7. Damages and suits caused by ruptures.
8. Costs of additional power and heat to maintain flow.
9. Loss of artistic or eye appeal.
10. Cost of corrosion research.

Since there are so many of these factors, it is necessary for the cost accountant and the chemical engineer to collaborate and check notes so as to evaluate the many economic vagaries involved. The following remarks will emphasize the importance of each of these factors.

In the past it has been customary to evaluate the losses due to corrosion as monetary costs involving the amounts of equipment or plant destroyed and requiring replacement. Corrosion, for this reason alone has been accused of causing more damage than fire and flood. It has also been estimated that nearly 40 percent of all the iron and steel fabricated is for the purposes of replacing metal lost by corrosion. Such costs alone run into many millions of dollars. One can cite any number of illustrations in almost any phase of industry where corrosion has necessitated replacement of expensive equipment in relatively short periods of time.

A shutdown or slowdown caused by equipment destruction or replacement can be much more expensive to a company than a shutdown or slowdown caused by strike. In the past war years a plant just was not supposed to find itself in the unhappy situation of reducing its production schedules. It is a tribute to industry that this was rarely necessary. But what a headache for the maintenance engineers! A slowdown in these years often caused complications because of the many barriers of shortages and priorities which plagued the maintenance staffs. In addition to the abnormal situations created by the war, any shutdown is costly to an organization dependent upon profit for its existence.

With labor costs closing up the profit lines, the factors of maintenance, inspection, and reinstallation become costs that must be included in any operation. It has been estimated that labor's share of maintenance costs is around 75 percent. The traditional methods of painting require considerable labor costs. Most structures require repainting every six months in order to combat corrosion. There is every reason to believe that these costs will not be reduced in the near future.

There are many means of reducing corrosion other than by routine maintenance. These means are by water treatment, phosphatizing, counter-electrolytic methods, the use of more resistant metals or non-

metals, etc. While such methods do reduce the ravages of corrosion if properly used, they do not come free, and they also require a certain amount of maintenance. Great progress has been made recently by these means in various industries.

Losses Through Leaks

It is almost impossible to estimate the losses in dollars incurred by the loss of product or processed materials through leaks caused by corrosion perforations. These losses often do not become manifest until a material balance shows a discrepancy or until the leak is visibly evident. When one considers the many millions of miles of water, gas, oil, and other pipe lines of different sizes, in different places, it is not inconceivable that many such pipes are losing appreciable products at this very moment. Instances are known where water pipe has been installed and corroded to perforation before a week of use has passed.

Contamination

The chemical industry is especially cognizant of material contamination by products of corrosion. The classic example of this case is in the preparation of phosphoric acid used for foodstuffs. This acid can be handled quite well with certain high-chromium irons but owing to the very slight corrosion of these alloys and the subsequent minute presence of chromium in the product, certain food and drug requirements are violated. The result is that a much less resistant iron is used which corrodes badly but the food and drug tolerances on iron contamination are not rigid to exclude high iron contents in phosphoric acid used for soft drinks or baking powders.

Slight contamination of some chemical agents will be sufficient to render some products unfit for chemical uses. This contamination by products of corrosion often will poison catalysts or biochemical processes sufficiently as to make their efficiency drop considerably.

The petroleum industry as well as the chemical industry is subject to the disturbing possibilities of lawsuits as a result of ruptures permitting product to spill into private or public property. Thus, the rupture of an oil pipe line near a stream used as a public water supply will cause, and has caused, sudden repercussions. Water leaks have also caused water damage to private property involving some complicated lawsuits with the town, city, or commonwealth.

Power and Heat

Power and heat, and the conveyance of these forms of energy, cost money. All power or heat lines, be they four feet, four inches, or one-fourth-inch in diameter become corroded over periods of time. The corrosion of such lines is often too slow to cause rupture but sufficient to cause the surface to acquire pits, rust, or layers of corrosion products which act to retard fluid or heat flow. It is well-known and conceded that iron and steel pipes may last for many years without actual rupture, but it is not so well-known that those same pipes may lose up to 50 percent of their carrying power within a few years. The facts are that fluid and heat flow are retarded in pipes the day after installation. This varies with different lines and under different conditions but it is quite evident to those interested in heat and fluid flow. The flow of heat or any fluid through a pipe is retarded by surface conditions. The rougher this surface becomes or the more thickly it becomes covered with products of corrosion, the greater the resistance to flow. The great barrier to heat flow is the film at the surface, and it is not unusual for the film coefficient to be lowered 50 percent over a short period. Considering the amounts of heat and fluid passing through pipe lines every moment one can visualize the large heat and power losses that are taking place.

It is known that appearances often have much to do with the efficiencies of laborers. Well-painted and neat equipment and buildings will cause the workers to take more pride and care in that equipment and plant. The presence of unsightly and corroded metal naturally will cause the workers to assume a careless attitude toward their work and equipment. Some of the more recent chemical installations have improved the appearances of the plants by the use of properly blended colors to assume artistic tastes. This has enhanced the pride of the workers to the extent of greater efficiencies and fewer accidents. The public, as well, takes pride in its local plants when they are well dressed. The additions of the intangible good will is also a consequent of tidy plants.

While research on corrosion problems is actually a charge, this activity has for its purpose the reduction of corrosion. There are many illustrations to prove that a few dollars spent on corrosion research reflect themselves in thousands of dollars saved. The discovery of the protective nature of phosphate treatments, the action of inhibitors, the use of cathodic protection, and other new means all developed in the laboratory at a minimum of expense. These methods are being improved and their applications are saving millions of dollars each year.

Corrosion research has actually only started and it has been only recently that manufacturers decided that something could be done to combat corrosion, and that protective methods had to be used. Technical literature is presenting more and more information on corrosion. In the past 20 years the frequency of corrosion literature has increased five-fold. The colleges and technical schools are now offering courses in corrosion and the chemical properties of structural materials. Now that the war is over and there can be a free exchange of technical information, some new barriers to corrosion will soon be revealed. Corrosion, the Billion-Dollar Thief, is soon to have many of his previous advantages exposed and circumvented.

Corrosion Theory

Any logical approach to the study of metallic materials of construction must take cognizance of the problems and characteristics of corrosion and corrosion prevention. Despite many obvious inconsistencies and exceptions, the electrochemical theory of corrosion serves best to evaluate and explain the many phenomena involved during the deterioration of metals or alloys by different chemical media.

In order to avoid a philosophical argument on why a metal or element goes into solution, we shall merely say, *per scienter*, that a tendency exists to a greater or lesser degree. A great deal has been written upon the solution pressures of the elements (tendency to go into solution) but the fundamental reason why one element goes into solution faster than another is unexplainable just as is chemical affinity.

Since some elements go into solution more readily than others, it seems reasonable that a table could be constructed showing the relative solution pressures of the various elements. Such a table can be tabulated,

and most chemists are familiar with its value. The standard for comparing the elements is hydrogen. While hydrogen is not to be compared with metals in the metallic sense, it serves very well as a standard in the chemical-solution sense. In a solution one-molal with respect to the hydrogen-ion concentration, hydrogen is arbitrarily given a zero potential. In other words, at this concentration the rate at which hydrogen goes into solution is equaled by the rate at which the hydrogen-ions form hydrogen molecules and go out of solution. All other elements fall into two distinct groups: those which have a tendency to go into a solution containing one molal concentration of their ions, and those which have a tendency to go out of such solutions of that concentration. At this point it is well to mention that this molal solution is one which contains one gram-ion of the metal dissolved in 1000 c. c. of water. As will be pointed out later a gram-ion can be quite different from a gram atom. Thus, if one gram molecular weight of $ZnSO_4$ were dissolved in 1000 c. c. of water, the Zn would be dissolved to give one gram atom of Zn solution, but since all of this $ZnSO_4$ would not ionize it would be less than one gram ion. This is scientifically referred to as activity and when the activity is one, or unity, you may consider the metal atoms as metal ions. So, one may say that when 27 grams of aluminum or 108 grams of silver are dissolved in 1000 grams of water that they only approach one molal solutions with respect to Al and Ag ion.

Electrochemical Series

Since these tendencies can be measured in terms of volts with respect to the hydrogen potential and since the tendencies are all different for the different elements, a table of the respective solution pressures of the elements can be constructed. This table is sometimes called the electrochemical series, the electrode potential, the electromotive, or the activity series, the oxidation-reduction series, etc. Table 1 lists some of these elements as found in some of the more recent books on electrochemistry.

TABLE 1.

Li	—3.02 volts
K	—2.92 volts
Na	—2.71 volts
Mg	—2.34 volts
Al	—1.67 volts
Mn	—1.05 volts
Zn	—0.76 volts
Cr	—0.71 volts
Fe	—0.44 volts
Cd	—0.40 volts
Ni	—0.24 volts
Sn	—0.14 volts
Pb	—0.12 volts
H	+0.00 Standard
Cu	+0.34 volts
Ag	+0.80 volts
Hg	+0.85 volts
Pt	+1.20 volts
Au	+1.42 volts

Inspection of Table 1 often tells one which elements go into solution easily and which ones with difficulty. Some of the elements, such as aluminum and chromium, however, exhibit non-tarnishing and corrosion-resisting properties so that they appear out of place in this table. Such elements demonstrate corrosion-resisting properties because of protective oxide films which cover their surfaces as a shield against corroding agents. When this protecting cover is removed the elements corrode readily and accordingly to the chart. These metals then exhibit properties of their protective films rather than of their true metallic natures. The table does not misinterpret; it measures the respective solution pressures of the elements, not of their oxide films.

If the reader will examine different electrode potential tables in other books and periodicals he may become confused because some tables give gold a negative potential and zinc a positive potential. The authors of one group state that lithium and metals above hydrogen are negative because, as those metals go into solution, the remaining atoms of these metals must retain the negative charges; thus they should be negative. The other group argues that because of thermodynamic consistency and reasoning they should be honored with a positive charge. The use of one sign or the other is purely conventional but also quite confusing. To encourage consistency, the Electrochemical Society went on record, after considerable thought, discussion, and debate, as adopting the metals above hydrogen as negative and those below as positive. This convention has now been adopted by the majority of scientific peoples here and abroad.

Some of the voltages given to these elements are subject to more accurate measurements, but any discrepancies should be less than one tenth of a volt for most cases. According to the convention of this table, lithium and cadmium are supposed to go into a one-molal solution of their own ions, leaving a negative charge on the remaining metal of —3.02 volts, 0.40 volts, respectively. Although copper, silver and gold are soluble in many media, they do not exhibit this solubility in one-molal solutions of their ions; in such media they show a tendency to go out of such solutions and bring their indicated positive charges to their electrodes.

Metals Trade Places

Everyone is familiar with the fact that an iron knife placed in a copper solution will become covered, more or less, with a coat of copper. This experiment shows that iron metal has a tendency to trade places with copper ions. If iron metal and copper metal could be placed in solutions containing one-molal iron and one-molal copper (one-molal ions), the iron would have a tendency, according to Table 1, to go into solution with a potential of —0.44 volt and the copper to go out of solution with a potential of +0.34 volt. The total driving force of the action would then be the algebraic difference of the two potentials —0.44 — (+0.34) = —0.78 volt, or simply the spread in volts between them on the table.

A more common illustration of the above action can be represented by the corrosion of a galvanized-iron pail. The metals present are iron and zinc. If the pail is scratched so that the iron and the zinc are both exposed to the corroding agent one might expect them both to go into solution; but fortunately only the zinc dissolves. Since the potential of zinc is higher than the potential of iron, zinc will have the greater tendency to dissolve. The iron remains unattacked as long as any zinc remains.

The elements below hydrogen sometimes are called electropositive elements or noble elements, while those above hydrogen are called electronegative or base elements. One may choose to classify them as "more zinc-like" and "more carbon-like" if desired. Convention dictates that nickel can be called more electropositive or more noble than iron or zinc, zinc

more noble than magnesium, copper more electronegative than silver, etc.

The Nernst Equation

The electrode potential series gives us a fair indication as to the solution tendencies of various elements and an exact relationship when the elements are compared in one-molal solution of their ions. When the solutions are not in the order of one-molal, or the concentrations are very different, then we cannot adhere too strictly to the table. It can be reasoned that as the number of ions of a solution decreases, the tendency for a metal to go into solution would increase; and if the ion-concentration increases, then the tendency to go into solution should decrease. This reasoning can be proved experimentally as well as mathematically. Nernst (in 1888) developed a valuable equation to show the relationship between electrode potential and concentration. Disregarding the development and derivation of this equation, which may be obtained from any standard text on physical chemistry, it may be stated as,

$$E = E_o + \frac{RT}{nF} \ln C \qquad (1)$$

where E is the potential at some concentration, C, which is in terms activity, E_o is the electrode potential as obtained from the electrode potential series, R is a constant, T the absolute temperature in Kelvin degrees, n the valence of the element, and F the value of the Faraday (96,494). At 25° C. equation (1) resolves itself into

$$E = E_o + \frac{0.059}{n} \log C \qquad (2)$$

If the activity is less than one, the log term results in a negative value thus making E less than, or rather, more negative than E_o. If the activity is more than one, then E will be more positive than E_o. It has been proved that the agreement between the calculated and the experimental values is quite close.

While it is always possible for an electropositive ion like copper to plate out on iron, it is sometimes possible for an electronegative ion to plate out on an electropositive element, such as zinc upon copper. It is a well-known fact that copper usually will deposit upon zinc when zinc is placed in solutions of copper. When cyanide solutions are employed, however, the concentration of copper ions reduces itself to such a low value that the copper potential becomes negative and passes that of zinc. When this happens, and any copper metal is present, the zinc in solution will deposit upon the copper. Another common illustration of this phenomenon is that of silver tarnishing where silver replaces the hydrogen in hydrogen sulfide. The phenomenon of the plating out of one metal on another from solutions is sometimes called cementation by the electrometallurgists. This property often is realized in certain stages of the electro-refining of metals such as copper and gold.

How intimately the electromotive series and the Nernst equation are connected with corrosion phenomena can be demonstrated by referring to Figure 1. A zinc electrode is placed in a solution of zinc sulfate which is separated by a porous membrane from a copper electrode immersed in a solution of copper sulfate. According to equation (1), the zinc potential will be

$$Zn = -0.76 + \frac{0.059}{n} \log C_{Zn^{++}}$$

and this resolves itself in a one-molal solution (assuming an activity of unity) to Zn = —0.76 volt. In a like manner, the copper potential becomes Cu = + 0.34 volt. When the two electrodes are connected with a wire, a current will flow with a potential equal to the algebraic difference of the single zinc and copper potentials, which is 1.10 volts. It makes no difference whether one wishes the final potential to be negative or positive; the important fact is that a difference of the two potentials with that numerical value is asserting itself. If the zinc or copper concentrations are other than one-molal, the following equation results:

$$E = (-0.76 + \frac{0.059}{n} \log C_{Zn^{++}}) - (+0.34 + \frac{0.059}{n} \log C_{Cu^{++}})$$

or by transposition:

$$E = -1.10 - \left(\frac{0.059}{1} \log \right) \frac{C_{Cu^{++}}}{C_{Zn^{++}}} \qquad (3)$$

so that if the copper activity is greater than that of the zinc, a greater potential than 1.10 volts will result. On the other hand, if a greater zinc than copper activity exists, a smaller potential will result.

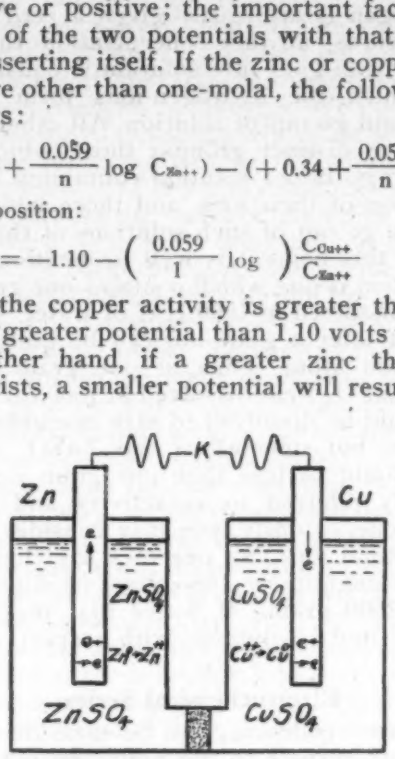

FIGURE 1.

It is well known that most corrosion is due to acid action, or simply a cell existing between hydrogen and a metal. Thus had we substituted an acid for the copper solution in the previous illustration and a hydrogen electrode for the copper electrode, our potential would be:

$$E = (-0.76 + \frac{0.059}{2} \log C_{Zn^{++}}) - (+0.00 + \frac{0.059}{n} \log C_{H^+})$$

or

$$E = -0.76 - \frac{0.059}{2} \log \frac{(C_{H^+})^2}{C_{Zn^{++}}} \qquad (4)$$

It can be seen, then, that the concentration of the acid solution has a great deal to do with the corrosion rate. With metals like nickel and tin, which are very close to hydrogen in the potential series, and with very weak acids, no appreciable potential should be present, and consequently no corrosion results, *caeteris paribus*.. With metals like iron the solution need not be even acid for the hydrogen to be replaced. Iron will displace hydrogen in water having a pH as high as 9.5.

Hydrogen Polarization and Overvoltage

It may be difficult to conceive of a hydrogen electrode, but such an electrode is quite possible. By definition, the hydrogen potential is zero in a solution with an activity of one-molal hydrogen ions. Hydrogen goes into solution, or out of solution, in two distinct steps

$$2H^+ + 2e \rightarrow 2H^\circ \rightarrow H_2 \qquad (5)$$

which are the ionic state to the atomic state and then to the molecular when it is going out of solution, and

the reverse of this order when it is going into solution.

The energy change from the atomic to the molecular state may be taken as zero when the process takes place at the surface of the platinized-platinum electrode; at the surface of other metals, however, there is an appreciable energy change attending this transfer. As a rule, molecular hydrogen will deposit out as bubbles at the surface of metals only at the expense of extra energy which can be measured in terms of volts. Platinized platinum, palladium, and graphite seem to afford the only surfaces which permit the evolution of hydrogen without expense of energy. All other metallic surfaces have a tendency to resist the change of atomic hydrogen to molecular hydrogen. This phenomenon is called hydrogen polarization. The nature of the metal surface, the concentration of the solution, and other factors may influence the degree of hydrogen polarization.

The elements can be arranged in the order of their tendency to resist the evolution of hydrogen at the surfaces by comparison with the evolution of hydrogen at the surface of platinized platinum. This value measured in terms of volts is called the hydrogen overvoltage of that element. Thus, hydrogen polarization and hydrogen overvoltage are closely related; the former represents the phenomenon and the latter, within limits, a definite numerical value. Table 2 gives a list of these values for some of the more common elements.

TABLE 2.

Zn = 0.70	Sn = 0.44	Cu = 0.33	Pt = 0.20
Hg = 0.61	Cr = 0.41	Ag = 0.33	Al = 0.18
Mn = 0.58	Ta = 0.39	Ni = 0.29	Pd = 0.00
Tl = 0.55	Sb = 0.38	W = 0.28	Pt-Pt = 0.00
Cd = 0.50	Au = 0.38	Fe = 0.24	
Pb = 0.45	C = 0.34	Co = 0.23	

One roughly can say that the soft metals, such as zinc, lead, and mercury, have a high hydrogen overvoltage, while the hard metals, such as nickel, iron, and platinum, have a low hydrogen overvoltage. This hydrogen polarization manifests itself in corrosion reactions in several ways.

Everyone familiar with the preparation of hydrogen from zinc and acids realizes that the pure metal stubbornly refuses to go into solution and displace hydrogen. The reason becomes quite apparent when one studies the potentials involved. According to equation (4) the potential will be in the order of 0.76 volt, while according to Table 2 the hydrogen overvoltage will be in the order of 0.70 volt, leaving a total of 0.06 volt to drive the reaction forward. One is safe in assuming that when the reaction is starting, the zinc concentration will be so low and the hydrogen concentration so high that a sufficient electromotive force will be generated to drive the reaction toward hydrogen evolution; but after the zinc surface has been attacked by the acid, the rate of diffusion of the zinc away from the active surface is so slow that its concentration at the immediate metal-acid interface asserts itself and the reaction immediately slows down. Before hydrogen can be evolved, this equation must hold:

$$E_m > E_h + E_v \qquad (6)$$

where E_m is the potential of the metal, E_h is the potential of the hydrogen, and E_v is the overvoltage of the hydrogen on the metal.

What frequently is done to promote this reaction between zinc and acid is to add a few drops of copper sulfate solution. The copper deposits out on the zinc, as previously explained, and the evolution of hydrogen begins immediately because the overvoltage of hydrogen on copper is of the order of 0.33 volt, and then, according to equation (6)

$$0.76 > 0.00 + 0.33$$

the reaction can proceed with a potential of 0.43 volt when the hydrogen potential is 0 by virtue of a one-molar acid solution. Eventually, the zinc concentration of the solution will become so high because of the zinc solution and the acid concentration so low because it is being used up that even this reaction will stop. Addition of traces of metals like nickel and platinum, with their lower overvoltages, should accelerate the reaction even more. That this is true can be easily ascertained.

The Theory of Local Action

The explanation of the galvanic action of metals during the corrosion of one of the elements was first made by a Frenchman named De la Rive more than 100 years ago and has since been called the theory of local elements, the theory of galvanic elements, or simple local action. Graphically the theory can be explained by Figure 2.

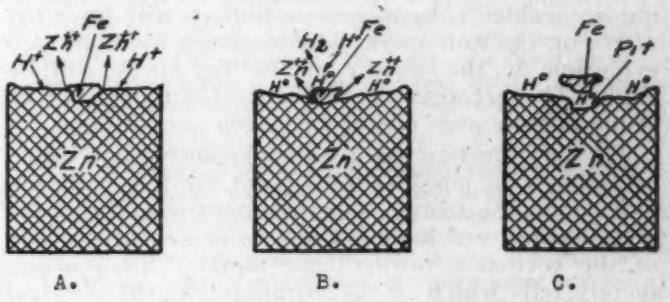

FIGURE 2.

A piece of metal, say zinc, contains some impurity, such as iron. The metal is placed in an acid solution and, since there is a greater tendency for the hydrogen to replace the zinc than to replace the iron, only the zinc will be attacked. The first stage of the action is represented by (A) the hydrogen ions are replacing the zinc and discharging at the surface of both the zinc and the irons as in (B). Actually, the hydrogen ions will discharge only on the iron surface, as the zinc surface acts as the anode. It will be noted that the action is confined to the interface of the liquid, zinc, and iron. Since it is easier for the hydrogen atoms to evolve at the surface of the iron than of the zinc (the overvoltage being lower), hydrogen evolution will center on the iron. This action continues with the formation of a cavity at the zinc-iron interface until finally all the zinc is corroded from the iron surface and the iron particle is dislodged, leaving a pit. If the piece of iron is too heavy to be carried out of the cavity by the liquid or gas currents, it remains and sinks deeper into the zinc as the zinc is being dissolved. The final result may be as shown in (C). If the iron particle had been washed away, then the action would cease unless other iron particles were present. What actually happens is that more impurities are uncovered as the corrosion proceeds and the corrosion rate speeds up. This increase in the reaction

velocity often reaches a maximum and then drops down again because the active zinc surface has been gradually replaced by the non-dissolving iron (or other) impurities. This phenomenon is sometimes called the period of induction.

In any study of corrosion phenomena, it is important to visualize the possible cell actions between the elements in the free and the ionic states. If a base metal is exposed to a solution containing ions of more noble elements there will be a tendency for the more electropositive ions to displace the base metal. If, for example, a zinc strip were exposed to a *medium containing* H, Fe, Al, Ag, and Hg ions, all but Al would tend to displace the zinc. In this case, the more noble Ag and Hg would have the greater displacing power, followed by H and Fe. This should be evident from study of Table 1. Now, take another example, that of a strip of zinc containing a *speck* of the following metals on its surface: Fe, Al, Ag, and Hg. If such a strip is exposed to an acid, or corroding medium, the Al will be sacrificed before any zinc is affected. After the aluminum is dissolved, the zinc is attacked. In all this reaction with the acid, the only cation present is H^+ and this has the tendency to displace the metals. As the hydrogen is displacing the Al and Zn, it appears as bubbles of molecular hydrogen. It will be possible for hydrogen to deposit out on the zinc or its impurity metals but, naturally, it will discharge where the least amount of energy is consumed (lowest hydrogen overvoltage). If this is the case, according to Table 2, hydrogen evolution will be most active on the iron speck. The tendency for hydrogen evolution on the surface of the Hg speck will be slight. The greatest electrochemical activity will be around those areas of low hydrogen overvoltage.

The *only* function a co-metal or impurity plays is that of acting as a possible focal point for the evolution hydrogen. The relative electromotive position of the metals concerned have nothing to do with the speed of the corrosion of the base metal. This position merely tells which of the elements has the greatest tendency to go into solution. The hydrogen overvoltage table tells which elements permit the most ready discharge of hydrogen.

Importance of Oxygen

Up to this point, reactions which have been discussed involve evolution of hydrogen. With many reactions the hydrogen-ion concentration is so low that it is impossible for a great enough potential to be developed that hydrogen can be evolved. Take, for instance, the corrosion of iron water pipes and outdoor iron and steel work which are subject to the action of water and air. Disregarding the effects of dissolved gases and salts, the hydrogen-ion concentration of water will be around 10^{-7} gram ions per liter, or have a pH of 7. This concentration is extremely low, and considering the possible overvoltages to be overcome, one can see why the visible evolution of hydrogen is prevented. It is possible to observe hydrogen evolution on platinum or palladium-base metal couples in pure water because of the low overvoltage, but these are exceptional cases.

The solubility of gases in liquids, such as water, makes it possible for a small amount of displaced hydrogen to dissolve in the corroding medium, diffuse through the liquid, and disappear to the atmosphere, but since this transfer is extremely slow, very little electrochemical action will take place. It follows then that if hydrogen is not removed from the surface of the couples, corrosion necessarily stops.

Oxygen has the ability to react with displaced hydrogen since the latter is in an active state. Oxygen is always present in solutions; consequently, by the processes of solution and diffusion will come in contact with the active metal-hydrogen surfaces. This, then is a means whereby discharged, but not evolved, hydrogen is constantly removed, resulting in a slow but steady rate of corrosion. This rate is dependent, of course, upon the solution and diffusion rates of the oxygen through the medium to the active surface. Oxygen in this role is called a depolarizer.

An excess of oxygen, on the other hand, may promote the formation of insoluble oxide films which inhibit attack, a phenomenon enjoyed by aluminum, magnesium and by many of the alloys of iron, nickel, and chromium. These slightly soluble oxide films are called passive films and contribute to the phenomenon known as passivity. It should be evident, then, that too little or too much oxygen might inhibit corrosion, while a definite amount might encourage corrosion. This observation brings one to an important phase of corrosion study—that of the influence of oxygen concentration.

Metals below hydrogen in the electromotive series such as copper, may form oxide films in the presence of copper which are soluble in most media. In this way oxygen may act in a primary way, attacking first the metal to form an oxide, which in turn is vulnerable to the action of the corroding medium. In all such cases corrosion is a direct function of the oxygen concentration. It is characteristic of the metals below hydrogen in the series that they corrode only in the presence of oxygen or oxidizing agents. This is not necessarily true if one considers the corrosion of noble metals in media which form slightly soluble or complex compounds such as silver and copper in cyanide or sulfide solutions.

In this section only those reactions have been considered which occur under so-called ideal conditions. Anyone familiar with the actual conditions involving corrosion realizes that there are a great number of factors which, individually and collectively, influence the corrosion of metals such as kind of solution, physical state of the metal, temperature of the solution, concentration, oxygen concentration, diffusion, light, colloids, etc. The presence of so many of these factors complicate and make difficult the ready interpretation of corrosion data.

End of Part 1—Parts 2 and 3 will appear in early issues.

Fundamental Requirements for Safe Arrangement of Drains and Vents

J. H. JOHNSON, Standard Oil Company (Indiana)

THE primary functions of drain and vent systems on oil processing units are to provide a means for quickly and safely disposing of oil and gas in an emergency, and to provide a means for safely draining and venting various parts of a unit during operation. Emergency disposal of hot oil is accomplished by releasing into a system where the oil is quenched with water, the liquid released into the sewer, and the vapors vented through a stack. Gases and liquid hydrocarbons of higher vapor pressure are disposed of by releasing into a blowdown drum. Vapor and gas from the drum are vented into a flare stack and burned at the top, and liquid is pumped out to tankage. Relief valves discharging liquid are usually vented into these blowdown systems, and relief valves discharging vapor are vented to the atmosphere at safe elevations.

Systems for draining equipment during operation are of two types: pressure or nonpressure. The former is a closed system from pressure source to disposal point and includes drainage from such points as pumps, dry drums, sample connections, and pocketed sections of lines. Nonpressure drains are from open funnels at telltales, pump packing glands, open sample connections, etc. These two types of drains are usually routed to separate underground sumps, which (for hot oils) may be the base of the blowdown stack, or (for cold oils) a sewer box compartment with a sump pump to recover the oil and pump it to slop tankage. Venting facilities are provided to safely dispose of noxious or hydrocarbon vapors from equipment by venting either into the process gas lines to the flare stack, or through an eductor discharging into a sump vent stack. Packing-gland vapor leakage at pumps and compressors is removed through ducts connected to an exhaust fan discharging at a safe location.

The author is an assistant head engineer in the engineering department, Standard Oil Company (Indiana), Whiting, Indiana. The paper was presented at a conference of executives and operating personnel of the company and its operating subsidiaries at French Lick, Indiana, May 5 to 9, 1947.

IT IS the purpose of this paper to describe the rather extensive facilities which are being provided to accomplish drain and vent functions on recently designed units. Owing to the large size and increased complexity of modern refinery units, the provision of adequate safety facilities is an important requisite in the design of these units. It has been intended in the design to provide for conceivable contingencies which might arise in the operation of the units, and yet at the same time to keep from complicating the drain and vent systems so that chances of operating errors are increased rather than decreased.

In the following discussion it is intended to illustrate the principles involved in the various types of blowdown and drain and vent systems employed, rather than to furnish a complete description of the facilities provided for any particular unit.

In case of a fire, or other emergency condition that necessitates quick removal of oil from process equipment, two types of blowdown facilities are available, the choice depending primarily on the temperature and vapor pressure of the stocks being handled. Hot oils of low vapor pressure are released into a system where they are cooled by quenching with water, the liquid and vapor are separated, the liquid is released into the refinery sewer, and the vapor is vented to the atmosphere through a stack. Gases and cold oils of higher vapor pressures are released into a drum which is vented through a flare stack. Any gas entering the drum and any vapor released in the drum are burned at the top of the stack, and the liquid is pumped out of the drum to tankage outside the unit. Cold oils at low pressures are simply pumped out directly from the process vessels to tankage, and do not require any special blowdown facilities.

Disposal of Hot Oil

A diagrammatic arrangement of facilities for emergency disposal of hot oil on catalytic cracking units is shown in Figure 1. This system is typical for most types of units processing hot oil.

The furnace can be blown down by opening air-motor-operated valves in the blowdown line from the convection section. The radiant section can be drained or blown down through manually operated gate valves in connections from the transfer lines. The furnace can be cleared by admitting steam through air-motor-operated valves to either the furnace-inlet line or the furnace out-let transfer line. In the latter case, steam flows back through the radiant section into the blowdown line.

All air-motor-operated valves on the unit are operated from a central control station, located to give maximum safety and accessibility. In this case, the operating station is located on an inside wall of the control room. Air-motor- rather than electric-motor-operated valves are used because they can be designed better to withstand high temperatures resulting from an external fire, and because they would not be incapacitated by possible electric-power failure during the emergency. Insulated housings are provided around the air-motor-operated valves for protection during a fire.

Air-motor-operated valves are generally provided in the blowdown lines from the convection section as shown in Figure 1, or in blowdown lines from the furnace inlets, to remove as much liquid oil from the furnace tubes as possible. However, in cases where there is a large volume of material at high pressure downstream of the furnace, as in a thermal cracking unit soaking drum, automatic blowdown from the transfer line may be provided.

Hot oil towers are generally blown down through

air-motor-operated valves in blowdown lines from the pump suction line leading from the bottom of the tower. The motor-operated valves are located as close to the suction line as possible to avoid long dead ends which might plug upstream of the valve.

Hot Oil Disposition

In addition to the above-described blowdown facilities for furnaces and towers, relief valves can be considered as an emergency means for disposing of hot oil. Relief valves on vessels and exchangers are designed to have sufficient capacity for relieving excessive pressures which might result from closed valves or other stoppage in outlet lines, failure of reflux or cooling systems, external fires, thermal expansion or vaporization in exchangers, or tube failure in exchangers. Any relief valves which release liquid oil are connected to the blowdown stack or to some closed system. On catalytic cracking units, for example, the slurry settler is a liquid-filled vessel, and the relief valves are vented to the blowdown stack.

Exchanger relief valves are released into a collecting drum which is vented to the blowdown stack, and from which liquid oil can be pumped out. Such a drum is usually provided when there are a large number of exchangers, so that relief-valve leakage can be easily detected and measured and can be kept out of the refinery sewer.

Vessel relief valves that discharge vapor are vented to the atmosphere through vent lines extended to safe elevations above surrounding equipment. Snuffing steam is connected to each vent through a combination steam and drain line (described under Drain Systems) so that discharged vapors can be diluted with steam to keep them from igniting or to extinguish fires at the vents. While in some cases it is desirable to discharge vapor relief valves into a closed system, atmospheric venting is generally provided, because of its simpler discharge piping arrangement. If a closed system is used, rather large discharge lines are needed to minimize back pressure; if dual relief valves are used, interlocked or 3-way shutoff valves are required in the discharge lines to allow removal of either relief valve.

Air-motor-operated valves, which are operated from the central control station, are provided in the fire-water lines to the quench nozzles. Fire water is also supplied to internal and external spray rings in the upper sections of the stack, through manually operated valves usually located in the water pump room.

Water and quenched oil are separated from steam and oil vapors in the base of the blowdown stack. In some cases, in order to obtain lower disengaging velocities, a quench and separating drum is also provided and is vented into the blowdown stack. Water and oil flow from the stack (or quench drum) through a sewer gas trap having its upstream side vented

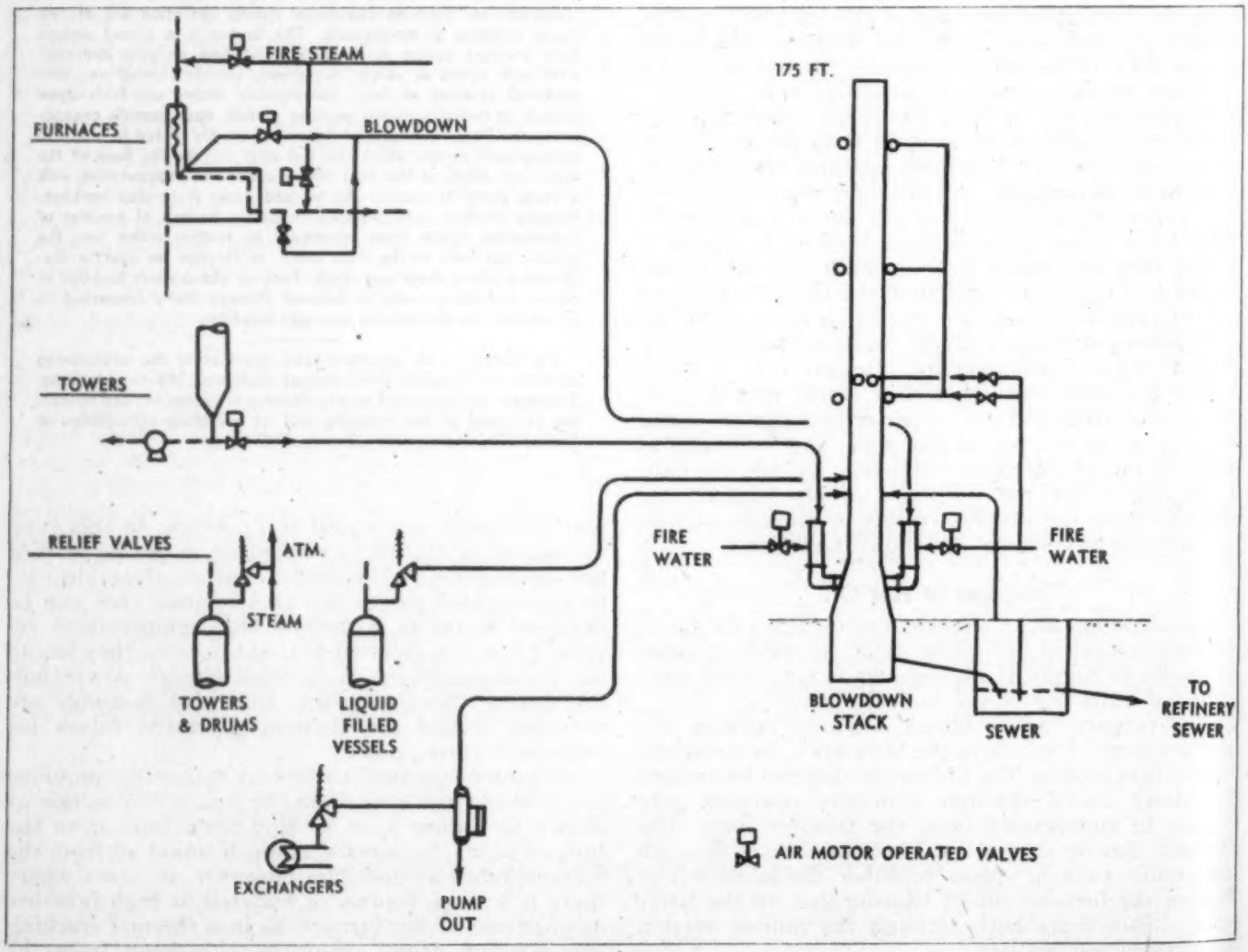

FIGURE 1
Emergency Disposal of Hot Oil

back to the stack, and then to the refinery sewer. The blowdown stack is located in the vicinity of the furnaces and hot towers to shorten the blowdown lines and to minimize fire hazard to other equipment. On large units it is preferable to run blowdown drainage separately to the refinery sewer rather than with other drainage from the unit, because of the relatively large volume to be handled, and because possible foaming of the oil-water mixture would cause resistance to flow of other drainage from the unit if connected to a common line. Although all drainage is ultimately mixed in the refinery sewer system, the refinery sewer is usually of ample capacity and has some water flow through it.

Owing to the large volume of oil and water handled when a unit is blown down, and considering that units are not blown down very frequently, it is usually impractical to install facilities for keeping blowdown oil out of the refinery sewer system. The blowdown oil is recovered at the refinery separators.

The system shown in Figure 1 is typical for most types of process units containing furnaces and hot oil towers. For delayed coking units, however, some deviations from this system are necessary, since the blowdown system is also used in steaming and washing the coke drums preparatory to decoking them. On each of these units a second blowdown drum, vented to the blowdown stack, is provided for steaming the coke drums when removing the unit from service. Condensed oil and water from steaming of the coke drums is collected in this blowdown drum and pumped to tankage for separation of the oil and water.

Disposal of Cold Oil and Gas

Cold oil at low vapor pressures (about 12 pounds RVP or less) is usually disposed of by simply pumping it out of the unit to a suitable storage tank. In some cases low-pressure cold oil is pumped through a gas-release tower outside of the unit before going to tankage. The gas-release tower is vented to a flare stack or into a refinery gas-collecting system.

For oils of higher vapor pressures, some other means of disposing of the relatively large quantity of vapors released on pressure reduction is required before the liquid can be sent to tankage. Figure 2 shows diagrammatically a typical blowdown system for disposing of light materials on vapor recovery and polymerization units.

The liquid oil is released into a blowdown drum provided with an external steam heating coil, to aid in vaporizing the light fractions and reducing the vapor pressure to a point where the liquid can be pumped to field storage. The vapors leaving the drum enter a flare stack 200 feet high, 24 inches in diameter, and reduced to 16 inches at the top. A pilot flame, which is always kept burning, ignites the vapors as they leave the top of the stack. The top swaged section, 9 feet long, is made of 18-8 chrome nickel steel to withstand the high temperature. A flame arrestor consisting of 4 layers of 40-mesh wire screen is provided near the top of the stack to prevent flame travel back through the stack in case of low gas velocity. Electric heating is provided to prevent plugging of the wire screens with ice. As further insurance against back-flash, a small amount of off-gas from the unit is bled into the stack continuously through a restriction orifice to keep air from entering the stack by "breathing." If the pilot light should go out, it may be relighted by a flame traveling up a series of gas jets inside of an open pipe, with a spark plug for igniting the lowest jet. Another method of lighting used on some units is by a gas flame propagated inside of a closed pipe by mixing gas and air and igniting the mixture with a spark plug.

Blowdown Design

The blowdown drum and flare stack are located a safe distance from any unit—usually about 300 feet or more, if space is available. On units where very light materials, such as propane, are blown down it is possible to get quite low temperatures in the blowdown header and in the line between the unit and the flare system. Low-nickel alloy steel pipe is used in some cases to provide sufficient impact strength at these low temperatures.

The typical arrangement shown for drum blowdown is used for disposing of oil in towers and drums which, after pumping out through coolers, would still have too high vapor pressure to handle in tankage outside the unit. On the Whiting Vapor Recovery Unit, for example, there are three such drums: the absorber feed accumulator, the lean oil still reflux drum, and the depropanizer reflux drum. The blowdown lines for these drums originate in the suction lines of the respective pumps inside of the pump room, and rise through the pump room to the electric-motor-operated valves located on the roof. The motor-operated valves are located at the high points in the lines so the downstream sides will drain into the blowdown header. Heated housings are provided to prevent freezing of the upstream lines in cold weather. Downstream of these valves there are restriction orifices with gate valve by-passes before the individual lines enter the blowdown header. The restriction orifices are sized so that, with the by-passes closed, the three drums can be blown down simultaneously without exceeding the estimated flare-burning capacity of 750,00 cubic feet of gas per hour. If only one drum is to be blown down, the restriction orifice could, of course, be partially by-passed. The operator would be guided by the appearance of the flame at the top of the stack in determining how far to open the by-pass.

The blowdown drum is sized to hold all the liquid remaining after flashing the contents of the three drums to atmospheric pressure, assuming normal operating levels in the drums initially. When this is not the case, it is necessary to hold off blowing down some of the vessels until some liquid can be pumped out of the blowdown drum. In either case, high-level alarms are provided to warn the operators that the drums are filling up.

While the various vessels in the unit are being blown down as described above, vessels containing material of sufficiently low vapor pressure after cooling are pumped out. In order to shut off reboiler steam to towers as quickly as possible, a solenoid valve operated from a remote push-button station is usually provided to vent the instrument air to the reboiler steam-control valve and thus close the valve.

Emergency Systems

Another use of the blowdown system is an emergency outlet for off-gas streams leaving the unit in case of a stoppage of the off-gas line, or in case use of the normal gas line is impossible for other reasons A manually operated gate valve is provided in the emergency gas-release line.

A similar emergency gas-release system is pro-

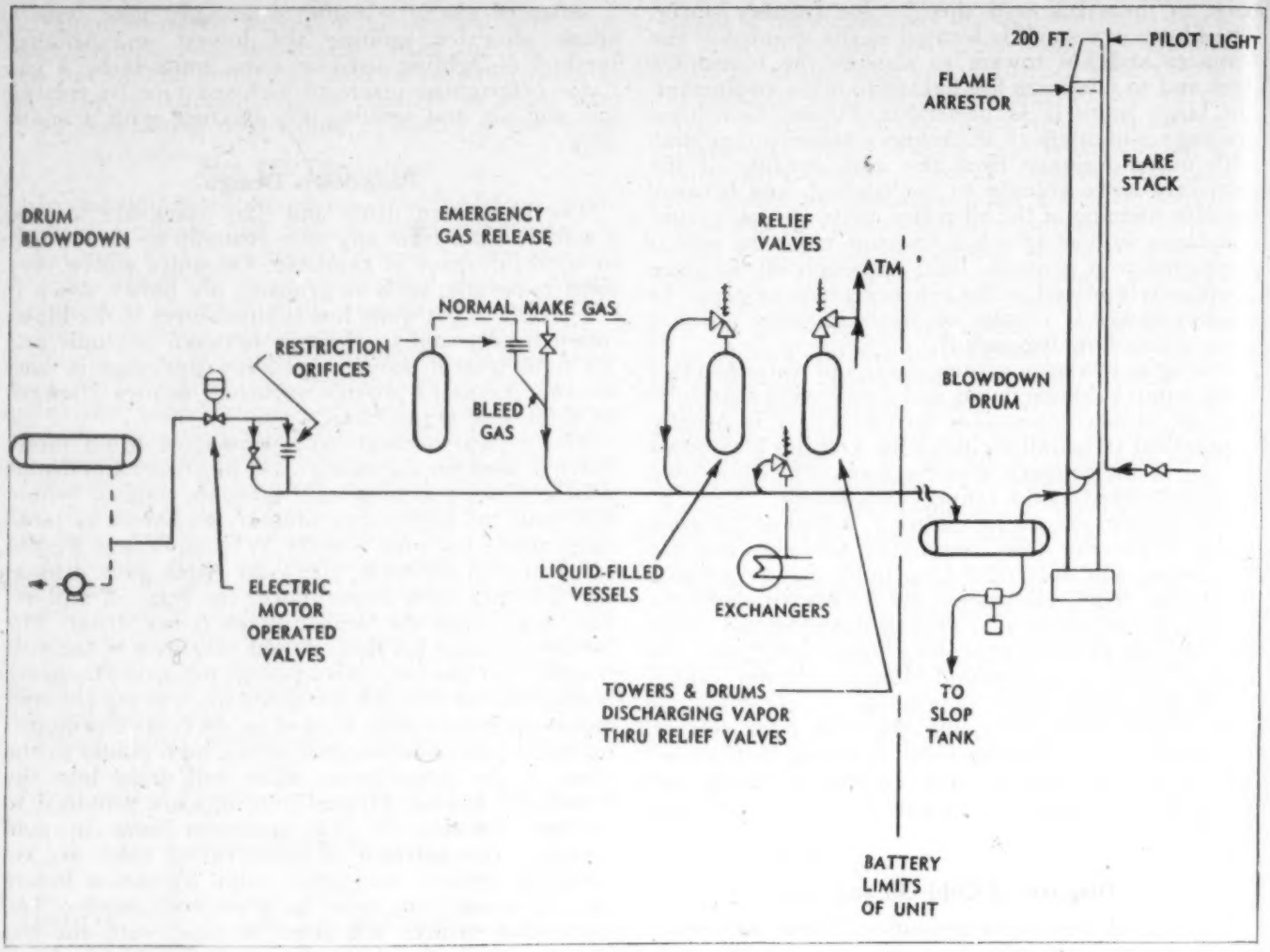

FIGURE 2
Emergency Disposal of Cold Oil and Gas

vided in the make-gas line to the suction of the gas compressors on catalytic cracking units, but in this case a control valve is provided which is set to open at a predetermined pressure a few pounds above the normal gas-compressor suction pressure. Thus, if there should be a compressor failure or if the suction pressure should go up to the setting on the control valve for any other reason, make gas will automatically be released to the flare. Because of the relatively low operating pressure of catalytic cracking units (about 5 psig at the compressor suction), and their dependence on proper pressure differentials across the catalyst slide valves, this is an important safety feature.

The blowdown system is also used to dispose of material released from relief valves on liquid-filled vessels. Relief valves that discharge vapor are ordinarily vented to the atmosphere at a safe elevation to eliminate the additional pipe and valving necessary to connect them to a closed system, as has been discussed under emergency disposal of hot oil.

Where feasible, exchanger relief-valve vents are piped into the blowdown system, as shown in Figure 2. However, since the blowdown lines are designed to drain to the blowdown drum, the blowdown line in the unit is usually rather high. In order to keep from pocketing the relief-valve discharges—and thus introducing a freezing hazard, the relief valves must be located above the blowdown line. This may necessitate rather long lines between the exchangers and relief valves, as well as additional platforming for access to the relief valves. Consequently, in some cases exchanger relief-valve vents are piped to the closed drain system through an underground header.

It has been the practice to provide relief valves on exchangers for protection against excessive pressures, which could result from vaporization or liquid expansion (due to blocking off the cold side before the hot side is cooled), tube failure, or external fire. On units now being designed (for Casper), however, relief valves are not being provided on exchangers where needed only for external fire, such as on the hot-oil side of exchangers where the hot side is at the higher pressure. In this case it would be necessary for the hot-oil side to be blocked off during a fire in order to build excessively high pressures, and this is not considered very likely.

Drain, Vent, and Pumpout Systems

The purpose of drain, vent, and pumpout systems provided on process units is to afford a means for safely disposing of oil and gas in lines and equipment as required during normal operation and during starting-up and shutting-down periods, and to keep as much of the oil and gas as possible out of the refinery sewer system. The systems provided necessarily vary with the type of unit, although there are a number of features common to most units.

Figure 3 shows diagrammatically the drain system

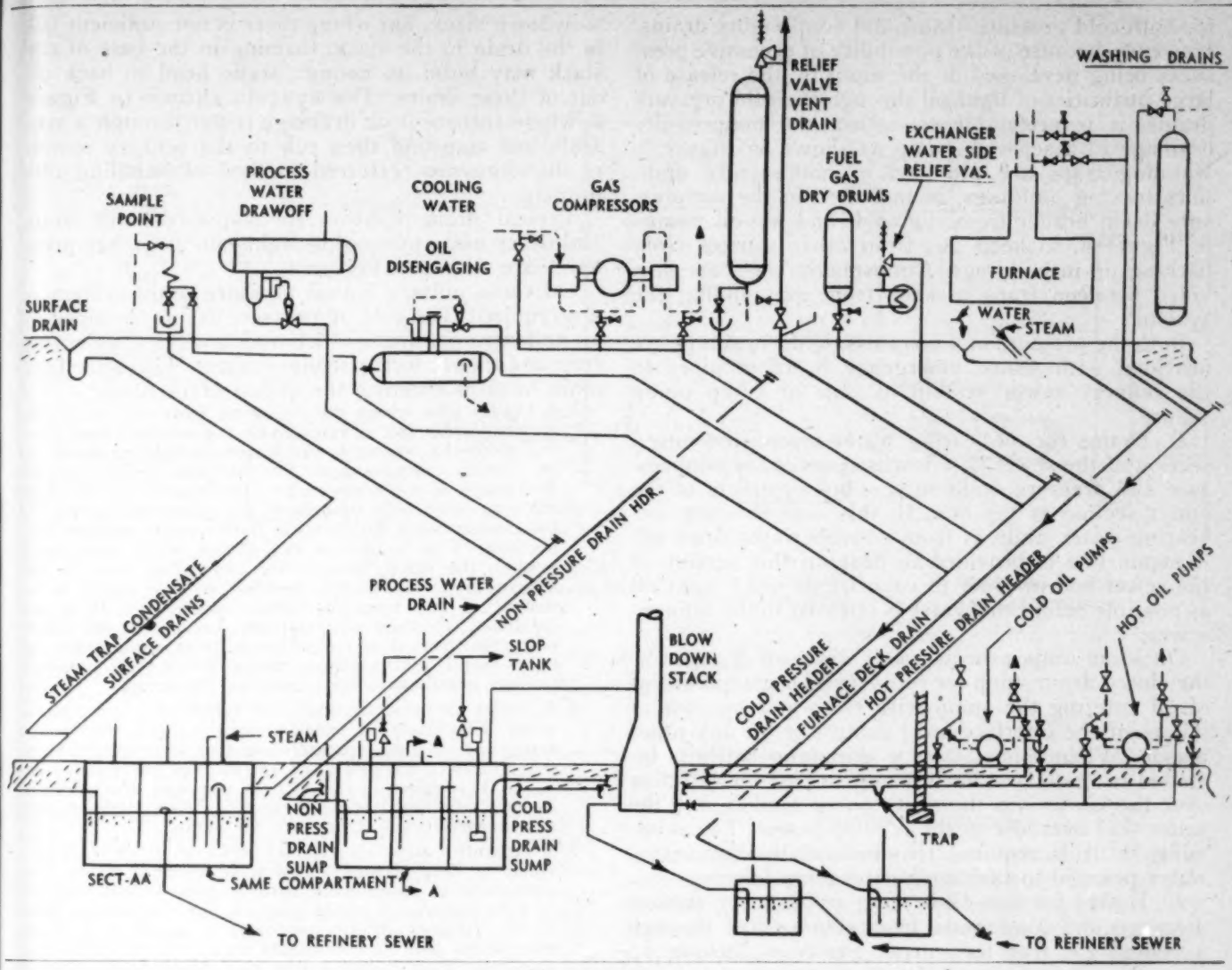

FIGURE 3
Catalytic Cracking Unit Drain Systems

provided for catalytic cracking units, and includes the following:

A. Cold-oil pressure drains are collected in an entirely closed system from the pressure source to disposal point. They include drains from the following:

1. Cold-oil pumps, for draining when shutting down, bleeding off the discharge for priming the pump, bleeding off the suction to eliminate water during the start-up, etc.
2. Gas-compressor suction, interstage, and discharge piping for draining during start-up.
3. Fuel-gas and other similar dry drums for draining small quantities of accumulated oil. Where there are larger quantities of oil to handle, such drums are connected to the pumpout system and pumped either to storage or to some process vessel.
4. Drain lines from relief-valve atmospheric vents to drain any liquid leakage through the relief valves.
5. Oil accumulation in the cooling-tower water-disengaging drum. In case of oil leakage into the water in shell and tube coolers, the oil and gas is accumulated in this drum and automatically drawn off through a control valve operated by interface-level control.
6. Connections for flushing out the sampling system before drawing a sample.

The cold-oil pressure drains are discharged into a separating sump, which is vented to the blowdown stack, and a sump pump is provided to pump the oil slop to tankage.

B. Hot-oil pressure drains are also collected in an entirely closed system from pressure source to disposal point, and are kept separate from the cold-oil pressure drains to avoid vaporization of light oil and water in the piping. Materials at temperatures higher than about 250° F. generally are put in the hot pressure drain system. The following drains are included:

1. From hot-oil pumps, which are drained for the same reasons as given under cold-oil pumps.
2. From the water-side relief valves of hot-oil coolers where oil-side pressure is higher than water-side pressure. In case of a tube failure, the relief valves would discharge hot oil.
3. Washing drains from the top of furnaces and towers. Although these are not actually hot-oil drains, some oil may be present in the wash water and there is too much water for the cold pressure drain sump pump to handle. It is put into the hot pressure drain header to disengage any oil vapor in the base of the blowdown stack before releasing to the sewer.

The hot-oil pressure drains are discharged to the base of the blowdown stack. Where this is not convenient a separate sump and water-quench system are provided.

C. Nonpressure drains are collected in open funnels and run into a vented collecting sump, and normally include drains from bearing brackets (packing leakage) on pumps, from oil sample connections, from telltales at various points, from atmospheric equipment, from sample-room sinks, etc. Usually hot-oil nonpressure drainage is not of sufficient quantity to warrant a separate system, and all nonpressure drainage is handled in a common header. If the nonpressure drain lines are properly sealed in an adequately vented collecting sump, it is possible to use the sump

for both cold pressure drains and nonpressure drains. However, because of the possibility of excessive pressures being developed in the sump by the release of large quantities of light oil through the cold pressure drains, it is preferable to collect the nonpressure drainage in a separate sump as shown in Figure 3. Running traps are provided in nonpressure drain lines leaving buildings, as indicated in the nonpressure drain header from the cold- and hot-oil pumps in Figure 3, to keep gas from other sources from backing up in buildings. Atmospheric vents are provided between traps to keep from gas binding the system.

Both the pressure and nonpressure drain sumps are provided with sealed emergency overflow pipes to the refinery sewer system in case of sump pump failure.

D. Drains for oil-bearing water are routed into a section of the sewer box downstream of the nonpressure and pressure drain sumps, but upstream of the outlet section of the box. In this case the only oil-bearing-water drain is from process-water draw-off. A steam line is provided to heat up this section of the sewer box in order to vaporize as much light oil as possible before the water is released to the refinery sewer.

On some units process-water draw-off is piped to the closed drain sump for recovery of large quantities of oil entering the sump with the water because of failure of the interface-level control or for any other reason. When this is done a skimming baffle is installed in the closed drain sump so that oil will flow over the baffle into the sump pump section, and the water will overflow to the refinery sewer. The skimming baffle is required to minimize the amount of water pumped to tankage by the sump pump.

E. Drains for non-oil-bearing water carry surface drainage and condensate from steam traps through a vented gas trap to prevent gas from backing up from the refinery sewer into these systems.

F. Deck drains under floor-fired furnaces are provided to handle hot-oil spillage through the floor of the furnace in case of a tube failure. Each drain is provided with a steam connection to act as an eductor to facilitate drainage, and running water is provided to seal the drains and insure against gas back-up. In some cases these drains are piped into the base of the blowdown stack, but where there is not sufficient fall in the drain to the stack, foaming in the base of the stack may build up enough static head to back oil out of these drains. The system shown in Figure 3, where furnace-deck drainage is put through a separate gas trap and then run to the refinery sewer, is therefore the preferred method of handling this drainage.

Typical drain systems for vapor-recovery units and other units processing light oils at higher pressures are shown in Figure 4.

On these units a hot-oil pressure drain system is not required. The cold-oil pressure drains are piped to an underground drum which overflows to a sewer gas trap and thence to the refinery sewer. There are four main headers entering the closed drain sump:

1. A header into which the following hydrocarbon drains are connected: (a) oil released by the interface-level control from the cooling-tower water-disengaging drum as on catalytic cracking units; (b) exchanger relief-valve oil discharges, if not connected to the blowdown and flare stack as previously described; (c) pump-casing drains; (d) closed drains for flushing hydrocarbon sample connections. This header is not sealed below the liquid level in the sump, because the connecting lines to the header are from closed systems so that there is no danger of gas from the sump backing up. It is not combined with any other streams because of the possibility that very low temperatures from vaporization of light liquid hydrocarbons might freeze the moisture present in other streams entering the sump.
2. A header for the drain lines from relief-valve atmospheric vents. This header is sealed under the liquid level in the sump and is run separately so that any vapors from other headers will not back out through the relief-valve vents. The valves in this system normally are left open so that any liquid leakage through relief valves vented to atmosphere will drain into the sump.
3. A separate header for reboiler steam condensate is provided to keep flashed steam from entering other systems, and to avoid back pressure due to vaporization of light material if mixed with the hot condensate. Most of the reboiler steam condensate is piped to a steam flash drum and the condensate recovered for boiler-feed purposes. This connection to the closed-drain sump is for emergency use, and for diverting a small amount of steam condensate into the sump to aid in vaporizing light hydrocarbons before releasing to the refinery sewer. This header is sealed under the water level in the sump.
4. A separate header for process-water draw-off, for closed washing drains from the top of towers and drums, for draining water from the towers through the pumpout system after water washing, and for water relief-valve

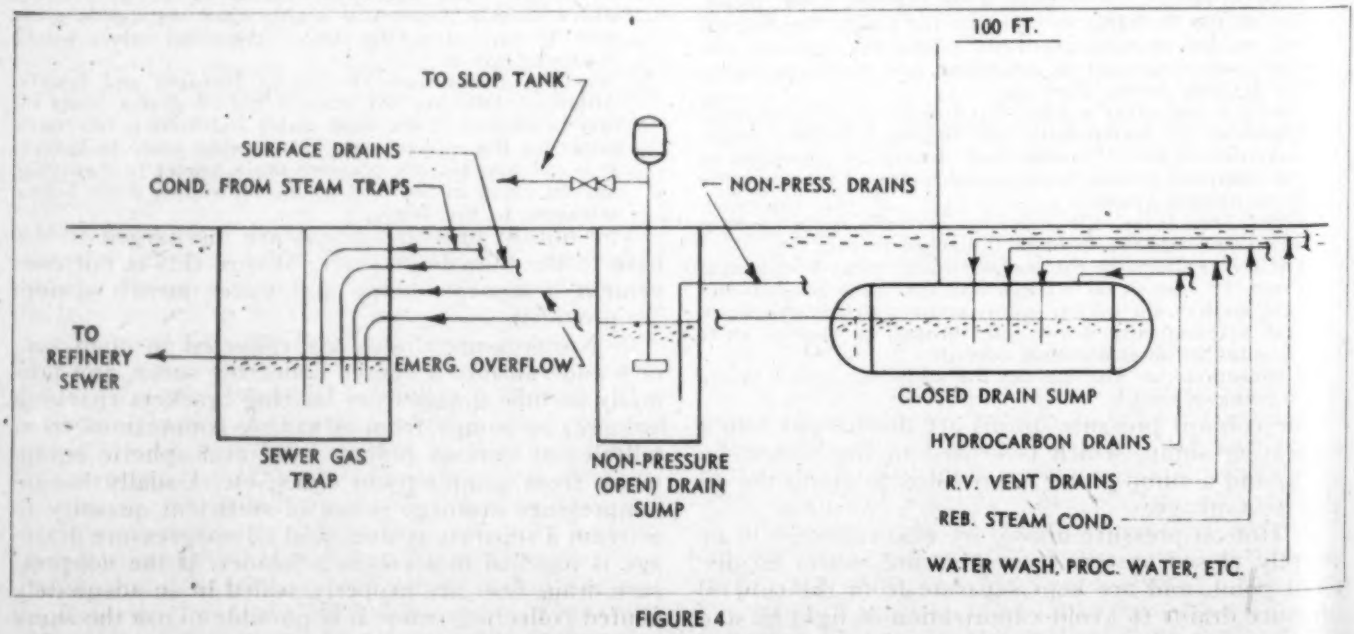

FIGURE 4
Vapor Recovery Unit Drain Systems

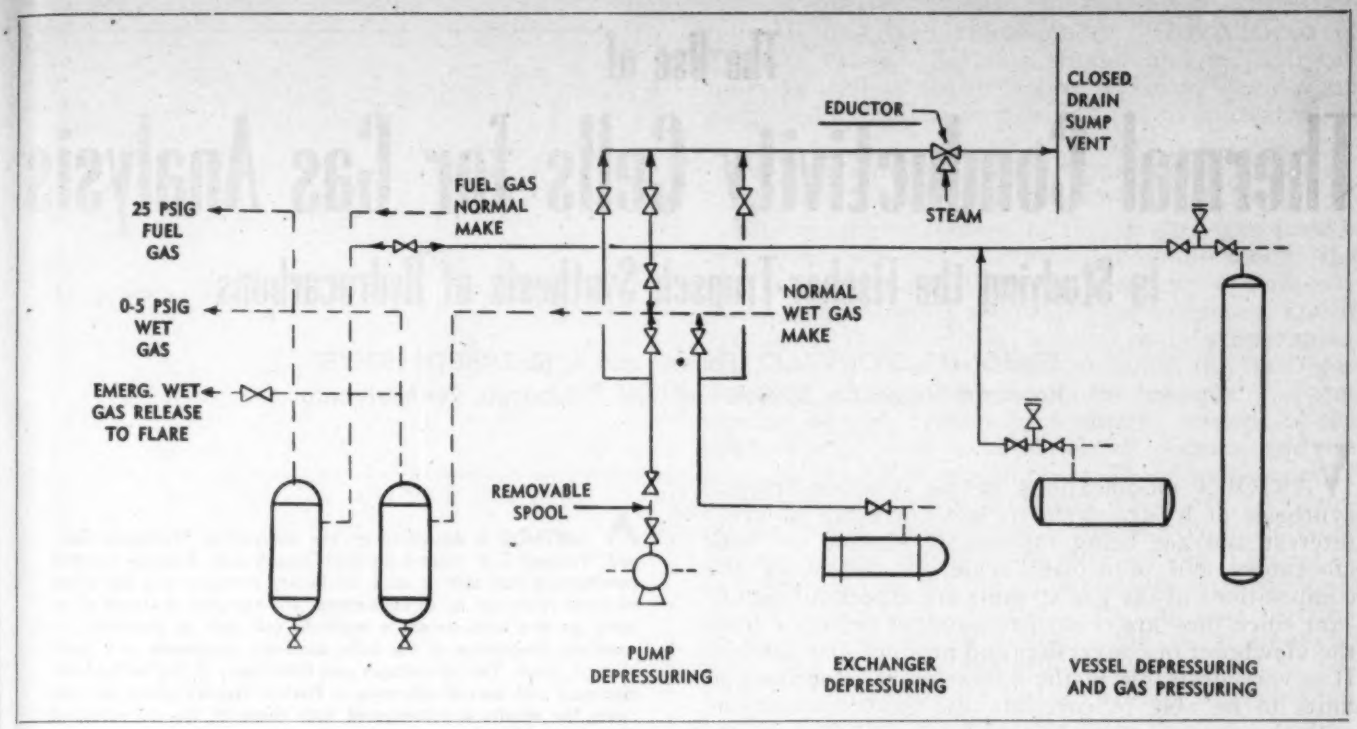

FIGURE 5
Vapor Recovery Unit Depressuring and Pressuring System

discharges. This header is also sealed under the water level in the sump to avoid gas backup.

Owing to the more volatile materials processed on these units as compared to the catalytic cracking units, it has been the practice usually not to provide a pump in the closed-drain sump. A large part of the oil entering the sump is vaporized, and the sump drums primarily are for disengaging vapor. An underground drum is usually provided because of the added disengaging time obtainable over that obtained in a sewer box compartment.

Vent Systems

The purpose of vent systems on process units is for safe disposal of noxious or hydrocarbon vapors, which are vented from process equipment during the course of operation, or in starting up and shutting down, or which might leak from such equipment. These systems include the following:

A. Stuffing-box exhaust systems are provided on all pumps and compressors handling noxious vapors or volatile hydrocarbons. The removal system consists of duct work leading from the stuffing boxes into the suction of an exhaust fan which discharges the vapors at a safe location.

B. Venting facilities are provided for handling volatile materials when shutting down the entire unit or when removing any individual piece of equipment from service. A typical venting system for vapor-recovery units is shown in Figure 5. Facilities are provided to depressure vessels, exchangers, and pumps by venting into the wet-gas system to reduce to about 0-5 psig. On units where no wet-gas system is available, pumps, exchangers, and vessels are depressured by releasing into the flare stack. A steam eductor is also provided for pulling down to a vacuum if desired. A spool, which is removed when the pump is in operation, is provided between block valves in each pump depressuring connection to avoid inadvertent excessive venting from the pumps. Vessels are first depressured into the fuel-gas system down to about 25 psig to avoid excessive venting into the wet-gas system. This connection to the fuel-gas system also serves for backing in fuel gas after steaming the vessels during start-up. In cases where gas at higher than fuel-gas pressure is available, connections are also provided for pressuring vessels with this gas.

Pumpout Systems

Pumpout systems are provided to handle relatively large quantities of oil which, when cooled, are of sufficiently low vapor pressure to be pumped to refinery tankage. In some instances, as on the bottom of towers, connections are provided to both the pumpout and drain systems. It is usually preferable to use the pumpout system for all except emergency conditions when the pumpout system may be inaccessible or too slow.

Connections to the pumpout system are usually provided from vessels and the oil sides of exchangers, and in some cases from large trapped lines. Two or more separate pumpout systems may be provided, depending on the materials to be handled. For example, on catalytic cracking units, light and heavy oils are handled in separate pumpout lines manifolded to a common pump; a separate slurry drain header, pump, and cooler box are provided which can be cross-connected with the heavy-oil pumpout system. When required, connections are provided so that the pumpout pump can be used to fill the unit with oil from an outside source for circulation during start-up. Where possible, process coolers are manifolded for use as pumpout coolers, rather than providing a separate cooler for this service.

In pilot-plant and laboratory-scale equipment, the smaller quantities of material involved usually necessitate some departures from the blowdown and drain and vent facilities described. However, the principles involved should be followed whenever required to provide a safe installation. Generally, relief valves and venting facilities are provided for pilot plants, but liquid disposal is accomplished by draining into barrels after the equipment is cool. Sewer gas traps are provided where necessary to prevent fires in the sewer system from spreading.

The Use of Thermal Conductivity Cells for Gas Analysis

In Studying the Fischer-Tropsch Synthesis of Hydrocarbons

EDMOND L. D'OUVILLE*, Fellow, and K. ELIZABETH HOWE,
Research Associate, Mellon Institute, Pittsburgh, Pennsylvania

A METHOD is described for the analysis of "Synthesis Gas" and "Product Gas" from a Fischer-Tropsch unit. A single thermal conductivity cell unit is used for binary mixtures and for other mixtures than can be so considered. For complex mixtures of as many as five components a multiple cell unit is described. A complete description of the cells, auxiliary equipment, and technique is given. The advantages and limitations of the method are discussed with special reference to Fischer-Tropsch gases. In some cases the results are compared with those of the conventional "Orsat" technique.

This work was done under sponsorship of Koppers Company, Inc., at Mellon Institute, Pittsburgh, Pennsylvania.

VARIOUS modifications of the Fischer-Tropsch synthesis of hydrocarbons are currently of great interest and are being intensively studied on both laboratory and pilot-plant scale. In this work the compositions of the gas streams are especially significant since they are related to catalyst behavior from the viewpoint of conversion and product distribution. It is very desirable in the operation of experimental units to be able to correlate the gas compositions with the operating conditions. In this laboratory, approximate instantaneous gas analyses have been obtained by means of thermal conductivity cells. This permitted the measurement of gas stream compositions simultaneously with temperature, pressure and space velocity and led to interesting correlations. Use of conventional Orsat equipment, the mass spectrometer, etc., were used to supplement the instantaneous analyses.

The use of thermal conductivity cells is likewise helpful in following the operation of gas generators, and in studying various gaseous reactions such as the combustion of hydrocarbons and the reforming of hydrocarbons with steam.

Single-cell units[1] can be used to determine the hydrogen content of binary mixtures such as synthesis gas. In some instances the hydrogen content of the product or "tail" gas can be estimated with fair accuracy with a single cell.

It is necessary to use multiple-cell units in conjunction with such auxiliaries as selective absorbtion and oxidation to determine the composition of the more complex gaseous mixtures. The method has been extended to the analysis of a five-component mixture such as the product gas from a cobalt-catalyst synthesis unit.

It is the object of this paper to describe the methods and apparatus used for the analyses of both synthesis and product gas streams in a bench-scale cobalt-catalyst Fischer-Tropsch unit.

The Analysis of Synthesis Gas by Single-Cell Units[2]

As a rule, synthesis gas consists primarily of H_2 and CO. The hydrogen content is usually within the range of from 50 to 70 volume-percent. A simple measurement of the potential set up by a single thermal conductivity cell can be used to establish the H_2 content or H_2 to CO ratio of a binary mixture. The hydrogen can be determined with considerable accuracy with readily available and inexpensive instruments. Within the range of 50 to 70 percent, H_2 can be estimated to within 0.5 percent of the actual.

Figure 1 is a calibration curve showing the relation between the CO content of a binary mixture of H_2 and CO and the potential in millivolts developed by a single cell using cell currents of 390 and 240 milliamperes. At the higher cell current the sensitivity is such that one millivolt is equivalent to about 1 percent CO. The above referred to accuracy can be obtained by controlling the cell current to within ± 2 ma. and reading the potentiometer to within ± 0.1 mv. At the lower cell current the sensitivity is

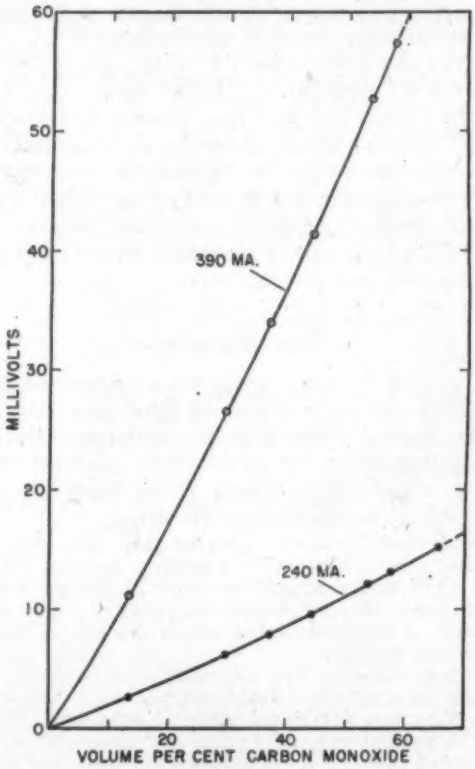

FIGURE 1

Relation between the CO content of a CO-H_2 mixture and the E.M.F. developed in a single cell employing H_2 as a reference gas.

*Present address: Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

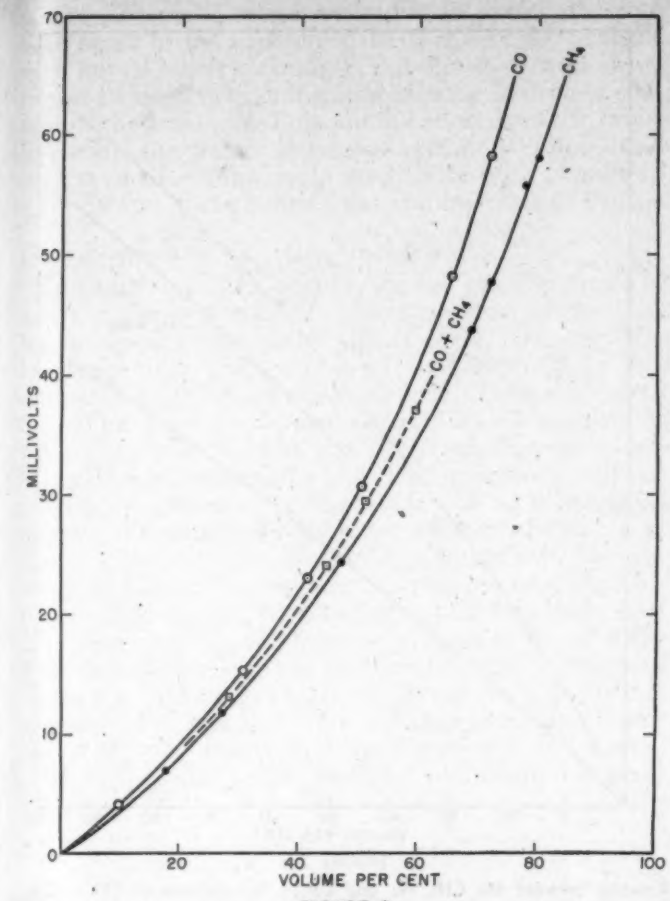

FIGURE 2

Relation between the CO, CH_4, and $CO + CH_4$ contents of $CO - H_2$, $CH_4 - H_2$, and $(CO + CH_4) - H_2$ mixtures and the E.M.F. developed in a cell for a current of 190 ma and H_2 as a reference gas.

reduced but the range of the instrument extended.

The hydrogen content can be determined with fair accuracy even if a few percent of such contaminants as N_2, CH_4 or C_2H_6 are present. The method is relatively sensitive to CO_2 and heavy gases such as propane, hence it is desirable that these, as well as water vapor, be removed before the method is applied.

If substantial amounts of CO_2, CH_4 and N_2 are present, a multiple-cell unit can be used to obtain the complete analysis. The operation of multiple-cell units is described below under "The Analysis of Product Gases." Suitable single- and multiple-cell units as well as the necessary auxiliary devices are described under the section devoted to apparatus.

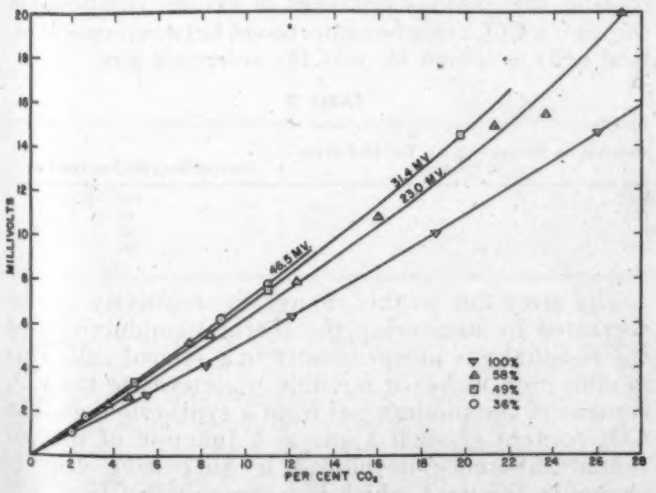

FIGURE 3

Relation between the difference in E.M.F. set up in identical cells in series and the CO_2 removed by absorption at an intermediate point. (Reference gas H_2 and cell current 190 Ma.) Relationships shown are H_2 contents of the CO_2-free gas of (1) 100 percent, (2) 58 percent, (3) 44 percent, and (4) 36 percent.

The Determination of Hydrogen in the Product or "Tail" Gas from a Fischer-Tropsch Unit

The hydrogen content of the product gas from a cobalt-catalyst unit is especially significant. If the synthesis reaction follows the ideal course and only liquid hydrocarbons and water are produced, and if synthesis gas contains H_2 and CO in the proper ratio, $(H_2:CO = 2)$, the hydrogen content of the "tail" gas would be identical with that of the feed gas. The production of CH_4 lowers the hydrogen content of the product gas by a combination of dilution and increased hydrogen consumption. The development of excessive catalyst temperatures which are very conducive to CH_4 formation are immediately reflected in the hydrogen content of the product gas. The use of a single-cell unit for the instantaneous or continuous determination of H_2 content of the "tail" gas provides an excellent means for following the operation of the unit. The complete analysis of the gas can be obtained at reasonable intervals by conventional methods using cumulative samples.

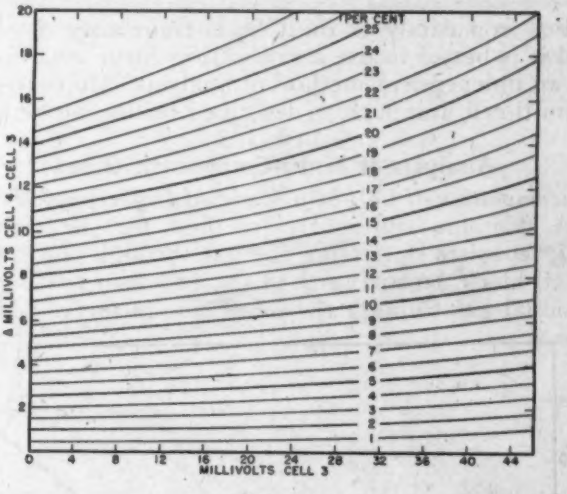

FIGURE 4

The CO_2 content of a gas as a function of the differential E.M.F. and the E.M.F. of the second cell—cross plot of Figure 3.

After the removal of the higher hydrocarbons by charcoal adsorption the product gas after drying usually contains a relatively high proportion of H_2, say 50 percent or more, CO and CH_4 in substantial amounts while the CO_2 is present only to the extent of about 1-2 percent or less. Either a calibration curve derived from actual samples of product gas and conventional analyses or the CO-H_2 calibration curve (Figure 1) can be used. The latter is possible because CO_2 and CH_4 have thermal conductivities below and above CO, and thus roughly compensate for each other when present in the usual proportions.

Figure 2 shows calibration curves indicating the relation between the potential developed in a single-cell unit and the composition of mixtures of H_2 and CO, H_2 and CH_4; and H_2 with an equi-mixture of CO and CH_4. In all cases, the cell current was 190 ma. and hydrogen the reference gas. From these curves it can be seen that only a small error is introduced when the CO-H_2 calibration curve is used for mixtures containing a few percent of methane. For example, at H_2 concentrations of 50 percent, the con-

tamination of the CO by as much as 10 percent CH_4 would result in an error of less than 0.5 percent of H_2. The cell is somewhat more sensitive to CO_2. However the concentration of CO_2 is proportionately lower and, as pointed out above, actually compensates for contamination by CH_4 when the CO calibration curve is used.

In general, H_2 determined by this method in "tail" gas from a Fischer-Tropsch unit using a cobalt catalyst checks the value determined by the conventional "Orsat" technique within 1 percent.

TABLE 1

GAS SAMPLE NO.	PERCENT H_2 BY VOLUME	
	Conductivity Cell	Orsat
70	67	66
71	55	55
72	51-57	55
73	60	60
74	not det'n	65
75	68	67
76	59	60
77	56	55
78	61	60
79	58	57
80	52	52
81	60	60
82	65	64
83	56.5	56
84	67	65
85	65	66
86	61	60

For iron catalysts the CO_2 is frequently too high and it is better to use a calibration curve established by an independent method of analysis. Alternatively, a multi-cell unit such as described below can be used.

Analysis of Multi-Component Gases

Determination of CO_2 by a Modified Differential Method

A common differential method for determining CO_2[3] consists of passing the gas through one side of a cell block, removing the CO_2, and then passing the residual gas through the other side of the cell block.

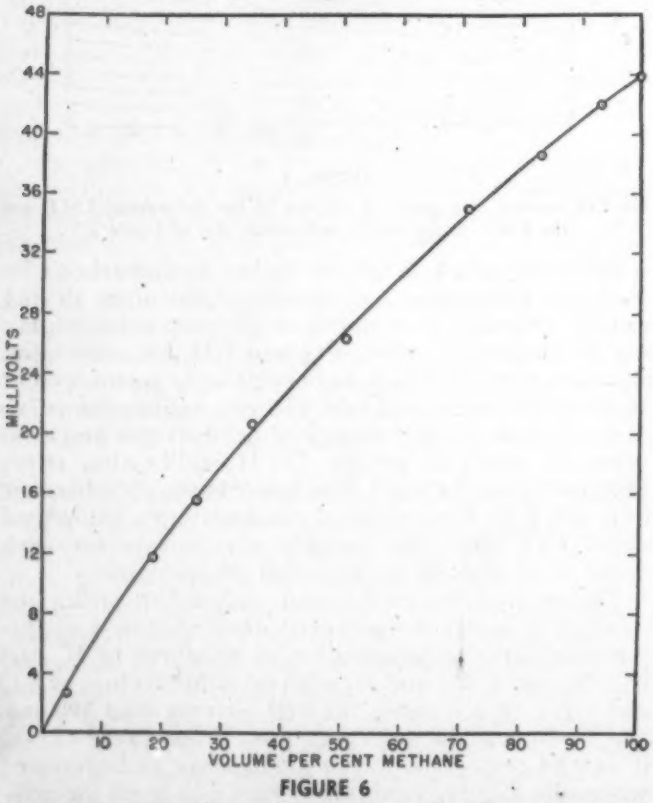

FIGURE 6

Relation between the CH_4 content of a $CH_4 - N_2$ mixture and the E.M.F. developed in a cell carrying a current of 180 Ma. and employing N_2 as a reference gas.

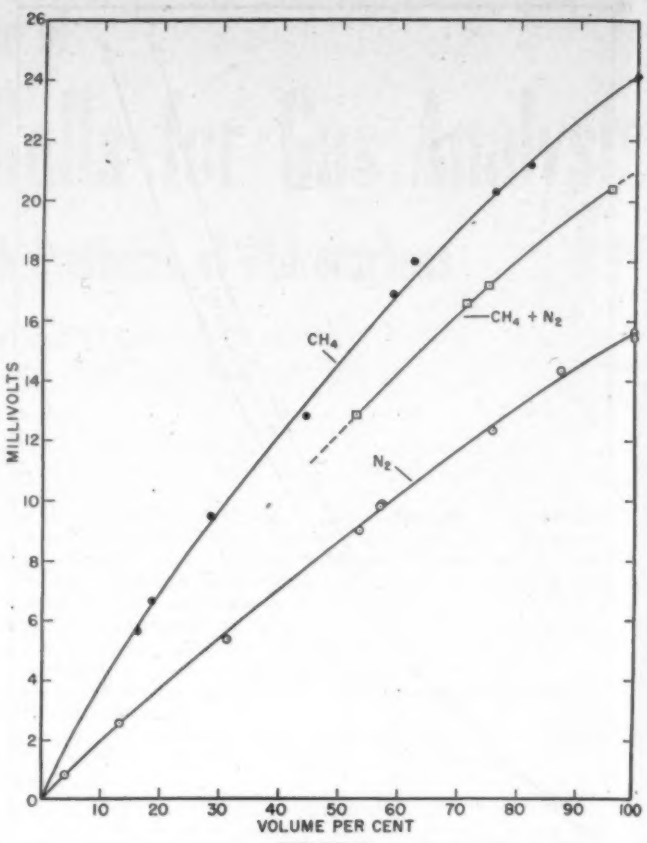

FIGURE 5

Relation between the CH_4, N_2, and $CH_4 + N_2$ contents of $CH_4 - CO_2$, $N_2 - CO_2$ and $(CH_4 + N_2) - CO_2$ mixtures and the E.M.F. developed in a cell carrying a current of 120 Ma. and employing CO_2 as reference gas.

The difference in thermal conductivity between the residual gas and the original gas is indicated as a potential difference, and is related to the amount of CO_2 removed. This method is satisfactory when the residual gas is of fairly uniform composition, as for example in flue gas. However, it is not fully satisfactory when the residual gas has varying percentages of H_2 as a constituent.

The relation between the potential difference developed and the hydrogen content (or thermal conductivity) of the residual gas is shown in Figure 3 and Table 2. This relationship was established by passing the gaseous mixtures of known composition through a CO_2 absorber interposed between two identical cells in which H_2 was the reference gas.

TABLE 2

Sensitivity in Percent CO_2 mv. For All Current of 190 ma.	Percent H_2 in the Residual Gas
1.8	100
1.5	58
1.4	49
1.35	36

The error due to this change in sensitivity can be corrected by measuring the thermal conductivity of the residual gas independently in a second cell. This modification makes it possible to determine the CO_2 content of the product gas from a synthesis unit. The CO_2 content of such a gas as a function of the potential difference developed in successive cells is shown in Figure 4 which is a cross-plot of Figure 3. The CO_2 is removed from the gas before entering the second cell. An "ascarite" absorption tube is satisfactory for this purpose.

Alternatively, the first cell also can be used as a differential cell. It can be adjusted to give a zero po-

tential difference when hydrogen is passed through both sides of the cell block. In this way CO_2 can be determined more accurately, but the first cell can no longer be used to give the approximate hydrogen content of the total gas. This modification does not interfere with the use of a second cell as a "pilot," and corrections for changes in sensitivity with change in composition of the diluent gas can be made as before.

Determination of CO, CH_4, and N_2

In addition to CO_2 and H_2 the tail gas contains CO and CH_4, and usually N_2. After removal of the CO_2 by absorption the residual gas (CO, H_2 CH_4, and N_2) is passed over CuO wire heated to 290° C. At this temperature the H_2 is oxidized to H_2O and the CO to CO_2. The dried gas from the CuO furnace consists of CO_2, CH_4, and N_2. The gas is passed through a cell using CO_2 as a reference gas. The sensitivity will depend upon the ratio of N_2 to CH_4. If no nitrogen is present the sensitivity for a cell current of 120 ma. is about 4 percent CO_2 per millivolt, while in the absence of CH_4 it is more nearly 6 percent CO_2 per millivolt. (See Figure 5.) On account of this difference it is necessary to determine the ratio of N_2 to CH_4. This is done by passing the gas through a cell with N_2 as a reference gas after removing the CO_2 by adsorption. The sensitivity in this case is about 2.5 percent CH_4 per millivolt. (See Figure 6.)

The triangular graph, Figure 7, shows the composition of the three-component system as a function of the relative thermal conductivities measured by the successive cells, Nos. 2 and 1 in Figures 10 and 11. This was derived from Figures 5 and 6.

The accuracy is not as high in the case of these gases because of the lower sensitivity, yet if the potentiometer can be read to ± 0.2 mv. and the cell current set to ± 2 ma. each constituent can be determined to within 1 to 2 percent. Also it should be remembered that these gases have been concentrated by the removal of H_2 and CO_2, and the deviations from the actual amounts will be reduced to 1 percent or less on the basis of the total gas, provided the CO_2 and H_2 are present to at least 50 percent as is the case in the Fischer-Tropsch product gas.

Although the percent H_2 can be estimated to within about 1 percent in ordinary Fischer-Tropsch tail gas by a single cell under certain conditions, nevertheless, after having determined the relative proportion of the diluents by the methods described above it is then possible to make a more exact estimation. After the CO_2 has been removed the residual gas consists of H_2, N_2, CO, and CH_4. The relative thermal conductivity of this gas is determined in the pilot cell (No. 3 in Figure 10). Since CO and N_2 have almost identical thermal conductivities they can be considered as a single gas. This permits the mixture to be treated as a three-component mixture. In Figure 8 the percent hydrogen is shown as a function of the pilot cell (No. 3) reading in millivolts and the composition of the diluent gas. Figure 8 is a cross plot of Figure 2.

Summarizing, the analysis of Fischer-Tropsch tail gas which usually consists of five components requires the use of four cells, two CO_2 absorbers, and a CuO furnace. The CO_4 is determined on the total gas by a modified differential method. After removing the H_2 as H_2O and converting the CO to CO_2, the relative amounts of CO_2, CH_4, and N_2 are established by the use of two cells, one before and one after the removal of the CO_2 obtained by oxidizing CO. The H_2 then can be estimated from the thermal conductivity of the mixture and the composition of the diluents. The CO_2 alone is determined on the total gas. The H_2 is determined on the carbon dioxide-free gas,

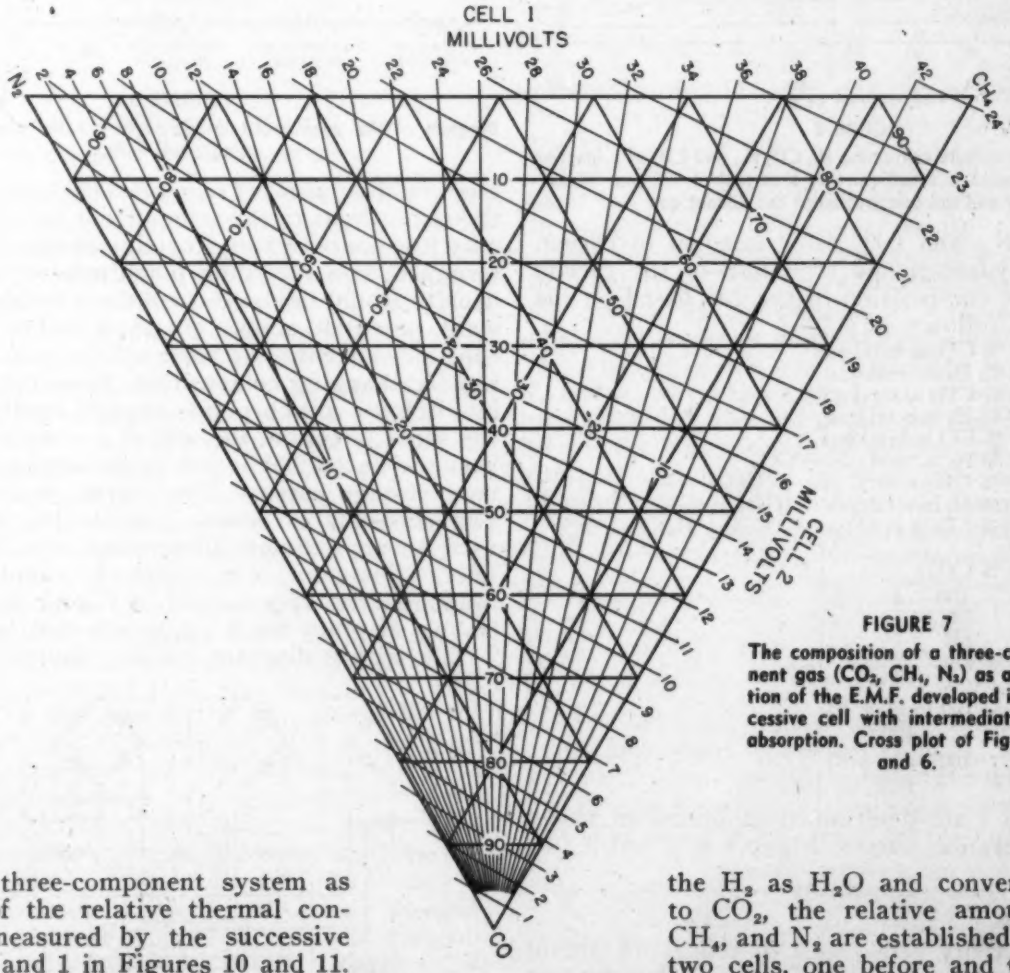

FIGURE 7

The composition of a three-component gas (CO_2, CH_4, N_2) as a function of the E.M.F. developed in successive cell with intermediate CO_2 absorption. Cross plot of Figures 5 and 6.

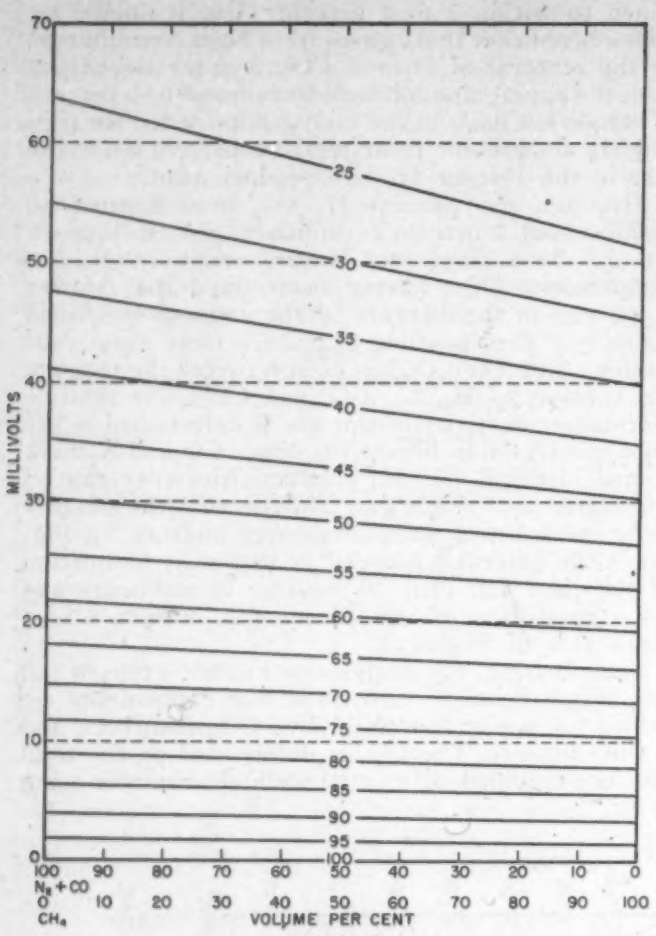

FIGURE 8

The H_2 content of a mixture containing H_2, CO, N_2, and CH_4 as a function of the E.M.F. developed in a cell carrying a current of 190 Ma. (H_2 reference) and the composition of the diluent gas.

and the CO, N_2, and CH_4 after removal of carbon dioxide and hydrogen and oxidation of the carbon monoxide. The composition of the gas based on the total gas is as follows, if

a = % CO_2 in total gas
b = % H_2 in total gas
c = % CH_4 in total gas
d = % N_2 in total gas
e = % CO in total gas
f = % H_2 in total gas — CO_2
g = % CH_4 in total gas — ($CO_2 + H_2$)
h = % N_2 in total gas — ($CO_2 + H_2$)
i = % CO in total gas — ($CO_2 + H_2$)

then

$$a = \% CO_2$$

$$b = f\,\frac{100 - a}{100}$$

$$c = g\,\frac{100 - (a + b)}{100}$$

$$d = h\,\frac{100 - (a + b)}{100}$$

$$e = i\,\frac{100 - (a + b)}{100}$$

a, f, g, h, and i are determined as described above from the calibration curves, Figures 4, 7 and 8.

Apparatus

The Cell Block

The conductivity cells[1] used in this work are of the diffusion type and are insensitive to flow rate up to about 100 liters per minute. They are of the bare-wire filament type. The safe cell current in air is 200 ma. and in hydrogen is 450 ma. The cell block is a 1.5-inch brass cube. All four resistances of the bridge are bathed in gas and are arranged in "series-parallel" as shown in Figure 9. They have approximately equal resistances. The zero adjustment or balancing resistors consist of two wires with Fahnstock fittings for slides. Once the slides are set the zero reading is fairly constant. However, the shift which probably results from vibration is sufficient to justify checking the zero point about once a month.

As can be seen from Figure 9, the four cells P_2, P_1, P_1, P_2 form an unbalanced bridge when two different gases P_1 and P_2 are passed through the cell block. Since a potentiometer rather than a galvanometer was used, the potential between points a and b was measured. The range of the potentiometer was 0—64 mv. A constant cell current was used. This usually was selected so that the full scale of the potentiometer could be used. It is necessary, however, to limit the cell current to the safe current for the cell where only low concentrations of diluent gas are being determined. If a recording potentiometer were used it usually would be more convenient to impress a constant potential across c and d rather than use a constant current. The same can be said for gases of rapidly changing composition. Since the gas streams in Fischer-Tropsch plants change slowly, usually in the same direction, the use of a constant current is very satisfactory. The source of current was an ordinary storage battery. The current was adjusted by two rheostats in series. The 16-ohm rheostat was used for approximate adjustment, and the 4-ohm for finer adjustment. The types of potentiometer and milliammeter are indicated in Figure 9 in which the wiring diagram for a single-cell unit is shown.

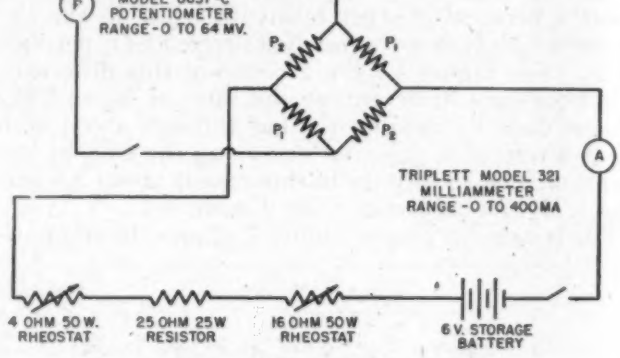

FIGURE 9

Diagram of the unbalanced bridge series-parallel circuit used in the single-cell units.

The wiring diagram for the multiple-cell unit is

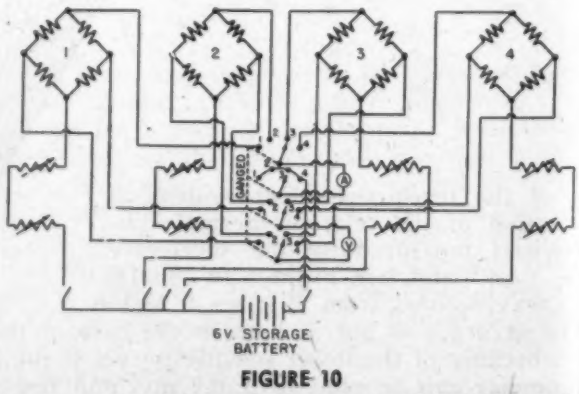

FIGURE 10

Diagram of the unbalanced bridge series-parallel circuits used in multiple-cell unit.

shown in Figure 10. The type of bridge, circuit, and control are the same except that each of the four cells can be cut in or out of the circuit by means of the four-bank double-throw switch indicated. Current passes through the cell only when the cell is being read. If a recording potentiometer is used it is most convenient to use a constant potential and pass the current through the cells continuously.

The analysis of five-component mixtures involves the use of a combination of chemical and physical methods. The flow diagram wherein these are combined is shown in Figure 11. It should be remembered that the composition of the gases changes relatively slow in the case of Fischer-Tropsch tail gas. The gas is dried in a drierite tube and then passed through cell 4 in which the reference gas is hydrogen. The gas emerging from cell 4 is passed through a CO_2 absorption tube filled with soda lime, ascarite, and

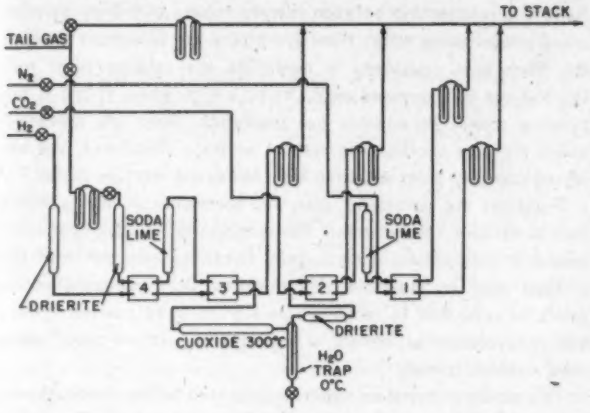

FIGURE 11
Flow diagram of the multiple-cell unit.

drierite. The ascarite serves as an indicator while the soda lime is easily removed since it does not cake. The drierite dries the gas before it enters cell 3. There is a time lag between cell 4 and cell 3 which depends on the size of the absorption tube and the volume of the lines. This lag can introduce an error in the determination of CO_2 by the differential method if the composition of the gas is changing rapidly. In such cases it is better to use a split stream and make the volumetric hold-up approximately equal so that the gases entering cells 4 and 3 at a given instant were removed from the line simultaneously. This is not necessary in the case of a gas that varies slowly and within definite limits. The lag can be reduced by using a higher flow rate, but the rate is limited by the capacity of the absorption tube. The exit gas from cell 3 is oxidized selectively over CuO heated to about 290° C. Fluctuations between 270 and 320° C. cause no serious error. Here the time lag is more marked than in the case of the CO_2 absorption between cells 4 and 3. This is because it is necessary to provide a larger tube for CuO and because there is a large volume reduction as a result of the removal of the H_2 as H_2O. Here again it may be necessary to use a split stream and controlled volumes of free space to minimize error due to lag. The charge of CuO wire used is about one pound. It can be reoxidized with air in a few minutes at the same temperature. The effluent from cell 2 is passed through a CO_2 absorber similar to the one previously described. The effluent from this absorber is usually only a small fraction of that passing through cell 4. If the N_2 content is very low it is often unnecessary to operate cell 1 continuously. Periodic determination can be made using a rapid gas rate and between readings slow rates can be used, thus prolonging absorber life.

When the Fischer-Tropsch unit is operated under pressure and a source of tail gas under some pressure is available, the desired flow of gas to the analyzer can be controlled by means of a needle valve. If the tail gas is not available under pressure it is necessary to use a small pump or aspirator to pass the gas through the cells and absorption tubes. A small bellows pump[4] was used and found to be very satisfactory. The gas rate could be easily controlled over a wide range. The pump when equipped with a steel bellows gave satisfactory service for several months. The checks were lubricated to aid in giving a gas-tight seal. The pump can be placed either before the analyzer, at a mid-point, or at the end.

Calibration and Testing of Cell Units

The units were calibrated by the dynamic method. The cylinders in which the gases were stored were equipped with two-stage pressure regulators and needle valves. Five wet-test meters were connected to a manifold. Shut-off valves were placed close to the manifold so that no gas could diffuse from the meters when not in use. The five gas meters agreed within one percent when a single gas was passed through them in series. The rate of gas flow was established by determining the time necessary for a given volume of gas to pass through the meter. This flow was fairly constant and several cell readings were taken during the period of timing. The gas was vented through a bubbler which put a constant back pressure on all the meters, and a side stream was passed through a drier and thence through the cell unit. The composition of the gas was calculated from the rates of flow which were sufficiently constant so that lag was not a factor. Individual meters were used for each gas so that the solubility of the gases in water did not affect the results.

The multiple-cell unit was tested on a five-component mixture. The composition of the mixture was determined by metering each component individually. Cell readings were taken periodically and the composition of the gas determined from Figures 4, 7, and 8. The values were put on a total gas basis using the formulas on page 530. The agreement between the composition established by metering the components and those determined by use of the multiple-cell unit was within 1 percent for all components.

The gases used in the calibration and test were:

GAS	Source	Purity Percent	Maximum Impurities
H_2	Air Co	99.9	O_2
CO_2	Pure Co.	99.0	.....
N_2	Linde	99.0	O_2
CH_4	Matheson	99.0	.....
CO	Matheson	90-95	N_2 4—5% H_2 2—3%

The impurities in the H_2, CO_2, N_2, and CH_4 were sufficiently low. The nitrogen in the carbon monoxide would have the same thermal conductivity and therefore have little, if any, effect on the calibration.

ACKNOWLEDGMENT

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REFERENCES

[1] G. A. Webb and G. S. Black, Determining Hydrogen in Gases, Anal. Ed. Ind. Chem. Vol. 16, p. 719, Nov. 15, 1944.
[2] T. L. Ibbs and A. A. Herst, The Thermal Conductivity of Gas Mixtures, Proc. Roy. Soc. 1929, A. 123, p. 134.
[3] H. A. Daynes, Gas Analysis by Measurement of Thermal Conductivity, 186, Cambridge University Press, p. 186.
[4] B. B. Corson and W. J. Cerveny, A Laboratory Bellows Pump, Anal. Ed. Ind. Eng. Chem. Vol. 14, p. 899, Nov. 15, 1942.

Rotation Speed in Continuous Filter Operation

E. J. REEVES, Technical Department, Refining Division
Magnolia Petroleum Company, Beaumont, Texas

THE general equations for batch filtrations are used in development of a relationship between filtrate volume and drum rotation speed in continuous rotary filter operations. For filtrations in which the filter base resistance is negligible the relative filter rate (V_2/V_1) can be expressed as $V_2/V_1 = \sqrt{t_1/t_2}$ where t, and t_2 are rotation speeds in minutes per revolution. Data are presented which indicate excellent agreement between calculated and observed capacity gains resulting from increased rotation speeds.

Equations are developed, also, for processing of stocks which have a variable solid content. These relationships show that filter output is constant for a given cake thickness irrespective of the method used to maintain this thickness, i.e., recirculation of solids or reduction in rotation speed when solid content is low, and recirculation of filtrate or increase in rotation speed when solid content is high.

This article is based on material presented before the Southwest Regional Meeting of the American Chemical Society, December 12-13, 1946, at Dallas, Texas, and has not been presented elsewhere.

FILTERING is one of the important processing steps employed in many chemical industries. Up to the present theoretical equations have been developed primarily for batch operations. Increased industrial use of solution filtration and rotary filters, particularly in petroleum refining, necessitates derivation of equations which are applicable to these procedures. Theoretical methods of determining the optimum dilution in solution filtration have been presented by the author in a previous publication.[2]

Several years ago Ruth and Kempe[3] developed a complex relation for rotary filter calculations. The intricacy of this equation and the large number of constants which must be determined experimentally have prevented its general use in engineering computations. The main factor causing these complications was inclusion of the filter base resistance. However, in many instances, such as in solvent dewaxing of lubricating oils, this variable can be neglected because of the much greater resistance of the wax cake. This permits derivation of a relatively simple formula which was found to be of considerable value in plant practice.

In the general filtration equation it is shown that filtering rate is inversely proportional to cake thickness. Development of maximum capacity depends, therefore, on maintenance of a minimum cake thickness. For continuous rotary filters this minimum is determined by the efficiency of the mechanical scrapers.

Some commercial filtration processes employ stocks which have varying solid material contents. The minimum cake thickness in these cases is maintained by changing the filter-drum rotation speed, recirculation of solids to filter charge, or recirculation of filtrate to charge liquid. In some isolated cases drum submergence is changed but mechanical considerations usually prohibit use of this method. The effect of the three former variables on filter capacity can be determined by mathematical analysis.

Nomenclature

V	Volume of filtrate
A	Area of filtering surface
Θ	Time of filtration
μ	Viscosity of filtrate
α	Average specific cake resistance
W	Weight of dry cake solids
r	Filter medium resistance
P	Pressure drop through filter medium and cake
w	Weight of dry cake solids per unit volume of filtrate
t	Time of filter rotation

Rotation Speed

Employing the general filtration equation in one of its many forms[1] the filtrate rate can be expressed as

$$\frac{dV}{d\Theta} = \frac{AP}{\mu\left[\alpha\left(\frac{W}{A}\right) + r\right]} \quad \ldots\ldots (1)$$

Filter medium resistance to flow in most cases is negligible when compared to cake resistance. If this factor is neglected, equation (1) integrated for constant pressure filtration gives the following relationship:

$$\frac{\Theta}{V/A} = \frac{\mu\alpha}{2P}\left(\frac{W}{A}\right) \quad \ldots\ldots (2)$$

The weight of dry cake solids in equation (2) may be replaced by the expression

$$W = wV \quad \ldots\ldots (3)$$

Thus, the filtrate-time relationship becomes

$$\frac{(V/A)^2}{\Theta} = \frac{2P}{\mu\alpha W} \quad \ldots\ldots (4)$$

The volume of filtrate per unit area and time of filtration change with the rotation speed. Filtration time is directly proportional to rotation speed which may be substituted for Θ in equation (4) with the addition of another constant. Changing the rotation speed does not affect cake permeability and the fil-

TABLE 1

Effect of Increased Filter Rotation Speed on Filtration Rates

Rotation Speed Ratio t_1/t_2	Relative Filter Rate V_2/V_1	Increase in Filter Capacity Percent Volume
1.00	1.00	0
1.25	1.12	12
1.50	1.22	22
1.75	1.32	32
2.00	1.41	41
2.25	1.50	50
2.50	1.58	58
2.75	1.66	66
3.00	1.73	73
3.25	1.80	80
3.50	1.87	87
3.75	1.93	93
4.00	2.00	100

trate-time relationship at the different speeds can be expressed therefore as:

$$\frac{(V_1/A_1)^2}{t_1} = \frac{(V_2/A_2)^2}{t_2} \quad \ldots\ldots(5)$$

The available filtering area in rotary filter operation is inversely proportional to the rotation speed, therefore, the relative area at the different speeds is:

$$\frac{A_1}{A_2} = \frac{t_2}{t_1} \quad \ldots\ldots(6)$$

Substituting equation (6) into equation (5) the final relationship is

$$V_2 = V_1\sqrt{\frac{t_1}{t_2}} \quad \ldots\ldots(7)$$

Through use of equation (7) the increase in filter capacity is readily calculated from the rotation speed. The calculated effect of rotation speed on filter capacity is shown in Table 1.

Calculated data using equation (7) agree with data observed in commercial ketone dewaxing unit operations. The data shown in Table 2 were obtained on a 500-square-foot rotary vacuum filter operating at 50 percent drum submergence. Filtrate viscosity was approximately 2.0 Cp at 0° F.

The actual capacity increase can be calculated from the relation

$$\frac{\text{slope of curve at higher speed}}{\text{slope of curve at lower speed}} - 1 \times 100 = \text{increase in capacity}$$

Using this equation the observed increase is found to be 40 percent and compares very favorably with the calculated 41 percent increase for these speed changes.

Recirculation of Solids

While processing low-solid-content materials the cake may pass under the mechanical scraper and blind filter canvas interstices. Recirculation of solids to filter charge is practiced frequently, to combat this operating difficulty. An alternate method is reduction of filter speed until the cake is thick enough to be discharged by the scraper. The operating procedure resulting in maximum utilization of filter capacity can be determined, also, by analysis of filtration variables.

TABLE 2

Increase in Filter Capacity Resulting from Increased Rotation Speed While Ketone Dewaxing a Furfural Treated Mid-Continent Distillate

ELAPSED STREAM TIME, Hrs.	CUMULATIVE FILTER DEMAND, BARRELS	
	At 4 MPR	At 2 MPR
0	0	0
1	158	219
2	310	436
3	463	648
4	616	862
5	768	1078
6	921	1290

From equation (2) it follows that the speed of rotation must be changed to maintain filtering rates when recirculation of solids is used. Assuming that the minimum dischargeable cake thickness is maintained in both of the above operations, their relative filtrate volume relationship can be expressed as

$$\frac{V_3/A_3}{\theta_3} = \frac{V_4/A_4}{\theta_4} \quad \ldots\ldots(8)$$

Correcting this equation for the available filtering area-time of rotation relationship as expressed in equation (6) the relative volumes filtered are

$$V_3 = V_4 \quad \ldots\ldots(9)$$

Equation (9) shows that filter output remains constant in these operations. Recirculation of solids to filter charge results only in additional operating difficulties and does not increase filter capacity.

Recirculation of Filtrate

Recirculation of filtrate frequently is employed while processing high-solid-content materials. The gain in filter capacity, if any, resulting from this type of operation can be determined by analysis of the equations given in the preceding section.

Assuming that the minimum dischargeable cake thickness (W/A) is maintained in operations with or without filtrate recirculation the right-hand portion of equation (2) is equivalent anad the relation between the filtrate volumes for these two conditions becomes

$$\frac{V_3/A_3}{\theta_3} = \frac{V_4/A_4}{\theta_4} \quad \ldots\ldots(10)$$

Since it is necessary to change the rotation speed to maintain a constant W/A ratio, equation 10 must be corrected for the change in filtering area. Substituting the relation given by equation 6 into equation 10 gives the final expression

$$V_3 = V_4 \quad \ldots\ldots(11)$$

Thus, recirculation of filtrate does not increase filter output.

Conclusions

The conclusions derived from the equations for constant-pressure filtration presented in this paper may be enumerated as follows:

1. Filter capacity increase resulting from higher rotation speeds can be calculated readily. When filter base resistance is negligible the filtrate volume is inversely proportional to the square root of the rotation speed (minutes per revolution).

2. Filtration rates remain constant for a given cake thickness irrespective of the operating procedure used to maintain this thickness. Sludge recirculation should be employed only when the cake is too thin to be discharged by the mechanical scraper at the maximum rotation speed (minutes per revolution).

3. Conversely, filtrate recirculation should be restricted to operations when excess capacity exists and the minimum cake thickness cannot be obtained at the minimum rotation speed.

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BIBLIOGRAPHY

[1] Perry, John H., "Chemical Engineers Handbook," p. 1654; McGraw-Hill Book Co., Inc., New York, New York, 1941.

[2] Reeves, E. J., Ind. & Eng. Chem. 39, No. 2 203-6 (1947).

[3] Ruth, Burrell F., and Kempe, Floyd L., Trans. Am. Inst. Chem. Engrs. 33, 34-83 (1937).

Practical Value of Empirical Equations

V. A. KALICHEVSKY, Consulting Chemical Engineer
Magnolia Petroleum Company, Beaumont, Texas

DEVELOPMENT and use of empirical equations is somewhat in disrepute among a large number of scientifically inclined persons and even practical engineers. A belief is often expressed that the only valid correlations are those based on rigid mathematical analysis of the fundamental laws of nature. However, in such arguments little consideration is given to the origin of the present-day science.

Knowledge is derived from experience and the ability of arriving at certain generalizations from a multitude of observed phenomena. Such generalizations are seldom, if ever, applied without reservations to the study of individual problems. Perfect gas laws, for instance, require considerable caution in their interpretation and can be used only over limited ranges without introducing substantial errors. The conflict between the electro-magnetic and quantum theories of light is another example of our confusion in the realm of science. Even the best established law of gravity is in contradiction with some of the recently-discovered experimental facts that led to the development of the theory of relativity which is not void, however, of its own shortcomings. Progress in science seems to destroy all our conventional theories without offering a solution to the problems of nature.

Many attempts to reconcile theory and practice are on record. They resort usually to the introduction of additional conceptions in the interpretations of the elusive natural phenomena but are at best only partially successful. Besides the resulting mathematical expressions are frequently cumbersome and unsuitable for every-day use.

The above discussion demonstrates that the existing theories are in reality empirical relationships subject to the same doubts and uncertainties as those of purely empirical origin. Some of the empirical formulas of yesterday or today may be elevated in the future to a status of a general law while the laws with which we are now familiar may become of historical interest only. For this reason empirical rules should not be easily discarded without subjecting them to a careful scrutiny with respect to their limitations. They may be even more valuable than those derived from theoretical considerations.

Two general methods may be used in setting up empirical equations. The first and most common one consists in fitting experimental data into a simple algebraic expression which shows the least deviation between the observed and calculated values. The second involves contrivance of some concept of the phenomena under investigation in order to derive a mathematical formula which is then tested in the usual manner. However, in such derivations the necessity of adhering to strict rules of mathematics becomes superfluous for the simple reason that even the basic concept is open to criticism. The frivolous use of mathematics has no further weakening effect on the already questionable validity of the assumption but may compensate occasionally for the faulty theory and thus lead to some useful relationship.

Irrespective of the approach selected to the problem, the number of constants in an empirical equation should be kept to a minimum. This follows from the fact that each constant is determined from one set of experimental data. If a large volume of data is needed, the empirical equation loses its significance because the desired information may be secured directly from experimental plots without resorting to mathematical interpolations or extrapolations. The simplest arrangement of points is a straight line. The straight line is expressed algebraically by means of an equation containing one or two constants depending whether the lines does or does not pass through the origin of the coordinates. Empirical equations should be restricted, therefore, as far as possible to these simplest expressions.

The most common equations involving straight-line plots include variables in the form of arithmetic numbers, their logarithms or reciprocals.[4] A total of nine arrangements of such variables is possible, namely,

$$y = ax + b$$
$$y = a \log x + b$$
$$y = \frac{a}{x} + b$$
$$\frac{1}{y} = ax + b$$
$$\frac{1}{y} = a \log x + b$$
$$\frac{1}{y} = \frac{a}{x} + b$$
$$\log y = ax + b$$
$$\log y = a \log x + b$$
$$\log y = \frac{a}{x} + b$$

The above equations may assume a variety of forms without changing the basic relationships. For instance $\log y = a \log x + b$ is equivalent to $y = a' \times b'$, or $\frac{1}{y} = \frac{a}{x} + b$ may be written as $x = a'y + b'xy$ where a and b with or without notation marks are constants.

Determination of numerical values of constants in the above equations is time-consuming. For preliminary investigations the problem is considerably simplified by the use of graphical methods. The following types of graph paper should be available:

1. Natural coordinates
2. Semi-logarithmic
3. Logarithmic
4. Natural and reciprocal coordinates
5. Reciprocal and logarthmic coordinates
6. Reciprocal coordinates

Occasionally, more than one straight-line plot may be secured showing that several equations can be employed for expressing the experimental data. The choice then becomes a matter of preference.

In setting up the equations the magnitude of experimental error involved in securing the data should be known. This permits a quick evaluation of the importance of observed deviations from the straight-line plots. If many experimental data are available deviations arising from this source will fall usually on both sides of the straight line.

TABLE 1

Observed and Calculated Compositions of Individual Phases of Partially Miscible Binary Mixtures at Various Temperatures

SYSTEM	Temp. °C.	COMPOSITION—(Percent Weight) A in B: Percent A Obs.	A in B: Percent A Calc.	A in B: Percent B Obs.	A in B: Percent B Calc.	B in A Observed: Percent A	B in A Observed: Percent B	Remarks
Formic acid-benzene	25	0.859	0.856	0.141	0.144	0.096	0.904	(1)
	30	0.849	0.850	0.151	0.150	0.104	0.896	
	40	0.822	0.821	0.178	0.179	0.130	0.870	
	50	0.790	0.784	0.210	0.216	0.166	0.834	
	60	0.743	0.730	0.257	0.270	0.221	0.779	
	70	0.649	0.645	0.351	0.355	0.314	0.686	
	73.2	0.482	0.504	0.518	0.496	0.482	0.518	
Methyl alcohol-hexane	10	0.735	0.724	0.265	0.276	0.032	0.968	(2)
	20	0.684	0.688	0.316	0.312	0.041	0.959	
	25	0.653	0.661	0.347	0.339	0.049	0.951	
	30	0.617	0.621	0.383	0.379	0.063	0.937	
	35	0.564	0.563	0.436	0.437	0.088	0.912	
	40	0.473	0.474	0.527	0.526	0.145	0.855	
	42.6	0.311	0.311	0.689	0.689	0.311	0.689	
Acetone-glycerine	40	0.849	0.848	0.151	0.152	0.104	0.896	(3)
	50	0.832	0.840	0.168	0.160	0.114	0.886	
	60	0.810	0.813	0.190	0.187	0.136	0.864	
	70	0.787	0.778	0.213	0.222	0.170	0.830	
	80	0.749	0.730	0.251	0.270	0.220	0.780	
	90	0.660	0.656	0.340	0.344	0.302	0.698	
	95	0.560	0.569	0.440	0.431	0.405	0.595	
	95.7	0.483	0.504	0.517	0.496	0.483	0.517	
Glycerine-isoamyl alcohol	20	0.974	0.957	0.026	0.043	0.182	0.818	(4)
	30	0.953	0.946	0.047	0.054	0.215	0.785	
	40	0.932	0.934	0.068	0.066	0.248	0.752	
	50	0.911	0.918	0.089	0.082	0.293	0.707	
	60	0.890	0.886	0.110	0.114	0.362	0.638	
	70	0.828	0.824	0.172	0.176	0.468	0.532	
	74.2	0.660	0.664	0.340	0.336	0.660	0.340	
Glycerine-benzaldehyde	90	0.948	0.944	0.052	0.056	0.634	0.966	(5)
	100	0.928	0.929	0.072	0.071	0.044	0.956	
	110	0.910	0.908	0.090	0.092	0.059	0.941	
	120	0.884	0.880	0.116	0.120	0.079	0.921	
	130	0.838	0.842	0.162	0.158	0.108	0.892	
	140	0.789	0.794	0.211	0.206	0.147	0.853	
	150	0.723	0.726	0.277	0.274	0.205	0.795	
	155	0.661	0.661	0.339	0.339	0.263	0.737	
	160	0.520	0.521	0.480	0.479	0.400	0.600	
	160.7	0.459	0.465	0.541	0.535	0.459	0.541	
Glycerine-salicylaldehyde	110	0.968	0.962	0.032	0.038	0.092	0.908	(6)
	120	0.953	0.952	0.047	0.048	0.113	0.887	
	130	0.937	0.939	0.063	0.061	0.134	0.866	
	140	0.920	0.924	0.080	0.076	0.158	0.842	
	150	0.900	0.908	0.100	0.092	0.187	0.813	
	160	0.864	0.872	0.136	0.128	0.230	0.770	
	170	0.778	0.798	0.222	0.207	0.320	0.680	
	175	0.700	0.711	0.300	0.289	0.402	0.598	
	176.6	0.552	0.537	0.448	0.463	0.552	0.448	
Glycerine-methylaniline	200	0.888	0.881	0.112	0.119	0.157	0.843	(7)
	210	0.846	0.846	0.154	0.154	0.201	0.799	
	215	0.805	0.808	0.195	0.192	0.247	0.753	
	220	0.736	0.740	0.264	0.259	0.326	0.674	
	224.5	0.54	0.54	0.46	0.46	0.54	0.46	
Glycerine-dimethylaniline	220	0.894	0.901	0.106	0.099	0.094	0.906	(8)
	240	0.867	0.871	0.133	0.129	0.123	0.877	
	260	0.838	0.844	0.162	0.162	0.156	0.844	
	270	0.799	0.797	0.201	0.203	0.197	0.803	
	280	0.710	0.710	0.290	0.290	0.286	0.714	
	285	0.617	0.616	0.383	0.384	0.382	0.618	
	287	0.500	0.500	0.500	0.500	0.500	0.500	
Phenol-octane	22.6	0.849	0.866	0.151	0.134	0.133	0.867	(9)
	25	0.840	0.853	0.160	0.147	0.147	0.853	
	30	0.822	0.829	0.178	0.171	0.176	0.824	
	35	0.798	0.802	0.202	0.198	0.208	0.792	
	40	0.764	0.760	0.236	0.240	0.257	0.743	
	45	0.706	0.697	0.294	0.303	0.332	0.668	
	48	0.635	0.627	0.365	0.373	0.416	0.584	
	49.5	0.53	0.53	0.47	0.47	0.53	0.47	
Glycerine-o-toluidine	100	0.922	0.919	0.078	0.081	0.124	0.876	(10)
	110	0.912	0.912	0.088	0.088	0.132	0.868	
	120	0.893	0.893	0.107	0.107	0.148	0.852	
	130	0.861	0.875	0.139	0.125	0.178	0.822	
	140	0.816	0.832	0.184	0.168	0.228	0.772	
	150	0.734	0.763	0.266	0.237	0.303	0.697	
	151.4	0.528	0.529	0.472	0.471	0.528	0.472	

Note: The following equations were employed for calculating the results presented in Table 1. In the equations A′ and B′ refer to percent weight of A and B components in the A and B phase, and A″ and B″ to percent weight of the two components in the B and A phase.

(1) $\log\left(\frac{B'}{A'}\right) = -0.826 \log\left(\frac{B''}{A''}\right) + 0.020$

(2) $\log\left(\frac{B'}{A'}\right) = -0.664 \log\left(\frac{B''}{A''}\right) + 0.565$

(3) $\log\left(\frac{B'}{A'}\right) = -0.815 \log\left(\frac{B''}{A''}\right) + 0.831$

(4) $\log\left(\frac{B'}{A'}\right) = -1.116 \log\left(\frac{B''}{A''}\right) - 0.616$

(5) $\log\left(\frac{B'}{A'}\right) = -0.933 \log\left(\frac{B''}{A''}\right) + 0.128$

(6) $\log\left(\frac{B'}{A'}\right) = -1.249 \log\left(\frac{B''}{A''}\right) - 0.176$

(7) $\log\left(\frac{B'}{A'}\right) = -\log\left(\frac{B''}{A''}\right) - 0.140$

(8) $\log\left(\frac{B'}{A'}\right) = -0.974 \log\left(\frac{B''}{A''}\right)$

(9) $\log\left(\frac{B'}{A'}\right) = -.876 \log\left(\frac{B''}{A''}\right) - 0.098$

(10) $\log\left(\frac{B'}{A'}\right) = -1.115 \log\left(\frac{B''}{A''}\right) - 0.104$

TABLE 2

Miscibility of Glycerine-Guaiacol Mixtures at Various Temperatures

Temp. °C.	COMPOSITION (Percent Weight) % A Obs.	% A Calc.	A in B Calc. †	% B Obs.	% B Calc.	Calc. †	A in B Observed: Percent A	A in B Observed: Percent B
39.5	56.0	56.0	....	44.0	44.0	....	56.0	44.0
40	62.8	62.5	....	37.2	37.5	....	48.0	52.0
45	71.5	73.2	....	28.5	26.8	....	34.0	66.0
50	74.8	75.7	....	25.2	24.3	....	30.5	69.5
55	76.3	76.4	....	23.7	23.6	....	29.6	70.4
60	76.5	76.6	....	23.5	23.4	....	29.3	70.7
65	75.9	76.4	74.9	24.1	23.6	25.1	29.6	70.4
70	74.4	75.7	74.2	25.6	24.3	25.8	30.6	69.4
75	71.7	74.1	72.8	28.3	25.9	27.2	32.7	67.3
80	67.5	69.9	69.1	32.5	30.1	30.9	38.2	61.8
82	64.3	64.1	63.7	35.7	35.9	36.3	46.0	54.0
83.5	57.0	55.1	55.8	43.0	44.9	44.2	57.0	43.0

Note: The following equations were employed for calculating the results presented in this table:

$$* \log\left(\frac{B'}{A'}\right) = -0.842 \log\left(\frac{B''}{A''}\right) - 0.193$$

$$\dagger \log\left(\frac{B'}{A'}\right) = -0.748 \log\left(\frac{B''}{A''}\right) - 0.193$$

In the above equations A′ and B′ refer to percent weight of A and B components in the A in B phase, and A″ and B″ to percent weight of two components in the B in A phase.

Failure of securing a straight-line plot may be traced sometimes to the improper selection of variables. For instance, pressure per unit area should be used in preference to total load, or absolute-temperature scales may have definite advantages over conventional thermometer readings.

As it was mentioned already, empirical equations involving three or more constants are of doubtful practical value. However, they may be derived, if necessary, by slightly modifying the equations already presented. Thus equation $y = a \log x + b$ leads to expressions $y = a \log (x + c) + b$ or $y = a \log (x + c) + b \log (x + d)$ while equation $y = \frac{a}{x} + b$ may find its counterparts in $y = \frac{a}{x + c} + b$ or $y = \frac{a}{x + c} + \frac{b}{x + d}$, or $y = \frac{a}{x + c} + \frac{b}{x} + d$, etc. other variations of a similar type are self-evident and need no further discussion.

The second method of arriving at empirical relationships is based on selecting some arbitrary assumption for explaining the observed phenomena. Free use of mathematics for setting up the equations of this type is permissible since the original theory is admittedly open to criticism.

For instance, assume that composition of binary mixtures within the region of partial miscibility depends on formation of unstable molecular clusters containing both types of molecules. For each individual arrangement the number of molecules of component B(N_b) per one molecule of component A would be constant, or

$N_b = K$; $N_{b'} = K'$; $N_{b''} = K''$; ..... $N_{bn} = K^n$

By multiplying these expressions the following relationship is secured

$N_b N_{b'} N_{b''} \ldots\ldots N_{bn} = K K' K'' \ldots\ldots K^n = K_o$

At this point another assumption may be introduced which does not answer requirements of rigid mathematics but simplifies the above expression, namely, that

$N_b N_{b'} N_{b''} \ldots\ldots N_{bn} = N^n{}_{bo} = K_o$

A similar method of reasoning applied to the second phase leads to the expression

$N^m{}_{ao} = K_o$

The two equations may be combined:

$N^n{}_{bo}\, N^m{}_{ao} = K_o\, K'_o = C$ (constant)

or

$n \log N_{bo} + m \log N_{ao} = C_o$

The latter equation involves two constants (n/C_o and m/C_o) suggesting a straight line logarithmic relationship for the two variables involved. Tables 1 and 2 demonstrate that is actually the case for a large number of non-aqueous binary mixtures.[1] Mixtures containing water as one of their constituents and shown in Table 3, are represented by broken lines indicating the probability of sharp changes in molecular associations at certain temperature levels.[1] Although mathematical derivations and even the fundamental assumption are open to criticism the final expression may find some practical application.

A similar example refers to free use of calculus. The above considerations applied to selective solvent extractions suggest the possibility of securing a straight-line logarithmic plot of the quantity of solvent used (S) against the fraction of the oil dissolved by the solvent (L). This was found to be actually the case in lubricating oil refining with solvents.[2,5] The corresponding differential equation is

$$\frac{dL}{dS} = K \frac{L}{S}$$

where K is constant.

The change in solubility with temperature (T) is frequently expressed by plotting the experimental data on a semilogarithmic paper. Such plots are often represented by a straight line. The corresponding differential equation is:

$$\frac{dL}{dT} = K'L$$

By multiplying the two equations the following expression is secured:

$$\left(\frac{dL}{dS}\right)\left(\frac{dL}{dT}\right) = K'' \frac{L^2}{S}$$

This equation does not give satisfactory correlations when it is integrated. However, by modifying it arbitrarily to

$$\frac{d^2L}{dS\,dT} = K'' \frac{L^2}{S}$$

good agreement between the calculated and observed data is obtained.

The second method of approaching the problem appears to be particularly helpful when selection of variables is not quite evident, thus introducing certain complications in graphical plots. However, in either case the resulting equations are empirical in nature and their validity depends entirely on the general agreement between the observed and calculated figures.

BIBLIOGRAPHY

[1] International Critical Tables 3, 336-98.

[2] Kalichevsky, V. A., Calculation of Solvent Extraction Equilibria. Am. Chem. Soc. Atlantic City Meeting, April 8-12, 1946.

[3] Kalichevsky, V. A., Natl. Petroleum News, 38, No. 32, R613-61, Aug. 7, 1946.

[4] Lipka, Joseph, Graphical and Mechanical Computation, Part II, Experimental Data, 260 pp. 1918, John Wiley and Sons, Inc., New York.

TABLE 3

Observed and Calculated Compositions of Individual Phases of Partially Miscible Binary Mixtures Undergoing Solvation or Association of Molecules at Various Temperature Levels

SYSTEM	Temp. °C.	COMPOSITION—(Percent Weight) A in B: Percent A Obs.	A in B: Percent A Calc.	A in B: Percent B Obs.	A in B: Percent B Calc.	B in A Observed: Percent A	B in A Observed: Percent B	Remarks
Glycerine-aceto-phenone	100	95.3	95.3	4.7	4.7	3.6	96.4	(1)
	110	94.4	94.5	5.6	5.5	4.4	95.6	
	120	93.3	93.3	6.7	6.7	5.7	94.3	
	130	92.0	91.9	8.0	8.1	7.4	92.6	
	140	90.3	90.1	9.7	9.9	9.6	90.4	
	150	88.2	88.1	11.8	11.9	12.1	87.9	
	160	85.4	85.6	14.6	14.4	15.5	84.5	
	170	81.6	81.6	18.4	18.4	20.7	79.3	
	170	81.6	81.4	18.4	18.2	20.7	79.3	(2)
	180	73.7	73.5	26.3	26.5	29.8	70.2	
	185.5	52	52	48	48	52	48	
Water-acetyl-acetone	30	4.9	4.9	95.1	95.1	84.6	15.4	(3)
	40	6.2	6.2	93.8	93.8	82.6	17.4	
	50	8.0	8.0	92.0	92.0	80.0	20.0	
	60	10.6	10.5	89.4	89.5	76.9	23.1	
	70	14.2	14.1	85.8	85.9	73.0	27.0	
	75	16.9	17.3	83.1	82.7	70.0	30.0	
	80	21.2	21.2	78.8	78.8	66.0	34.0	(4)
	87.7	43.5	56.5	56.5	56.5	43.5	56.5	
Water-isobutyl alcohol	30	17.1	16.7	82.9	83.3	92.25	7.75	(5)
	40	18.2	18.8	81.8	81.2	92.75	7.25	
	50	19.4	19.4	80.6	80.6	92.90	7.10	
	60	20.8	21.4	79.2	78.6	92.9	7.1	(6)
	70	22.4	21.8	77.6	78.2	92.8	7.2	
	80	24.4	23.2	75.6	76.8	92.45	7.55	
	90	26.5	25.8	73.5	74.2	91.8	8.2	
	100	29.8	30.4	70.2	69.6	90.65	9.35	
	100	29.8	29.5	70.2	70.5	90.65	9.35	(7)
	105	31.1	31.4	68.9	68.6	89.7	10.3	
	110	33.0	33.0	67.0	67.0	88.7	11.3	
	115	35.25	34.7	64.75	65.3	87.7	12.3	
	120	38.3	38.3	61.7	61.7	85.15	14.85	
	125	42.53	41.9	57.47	58.1	82.0	18.0	(8)
	130	45.75	49.5	51.25	50.5	76.4	23.6	
	132	63.2	63.2	36.8	36.8	63.2	36.8	
Water-isobuty-ric acid	0	20	20.9	80	0.791	0.842	0.158	(9)
	5	25.5	24.6	74.5	0.754	0.835	0.165	
	10	31.1	31.2	68.9	0.688	0.823	0.177	
	15	36.1	36.1	63.9	63.9	80.6	19.4	(10)
	20	41.7	41.8	58.3	58.2	77.5	22.5	
	21	43.4	43.3	56.6	56.7	76.7	23.3	
	22	45.7	44.5	54.3	54.5	75.4	24.6	
	23	48.5	48.5	51.5	51.5	73.6	26.4	
	24	53.4	53.4	46.6	46.6	70.6	29.4	
	24	53.4	53.4	46.6	46.6	70.6	29.4	(11)
	24.5	62	62	38	38	62	38	

Note: The following equations were employed for calculating the results presented in this table:

(1) $\log\left(\frac{B'}{A'}\right) = -0.769 \log\left(\frac{B''}{A''}\right) - 0.208$

(2) $\log\left(\frac{B'}{A'}\right) = -\log\left(\frac{B''}{A''}\right) - 0.070$

(3) $\log\left(\frac{B'}{A}\right) = -1.622 \log\left(\frac{B''}{A''}\right) + 0.085$

(4) $\log\left(\frac{B'}{A'}\right) = -1.137 \log\left(\frac{B''}{A''}\right) + 0.244$

(5) $\log\left(\frac{B'}{A'}\right) = 2 \log\left(\frac{B''}{A''}\right) + 2.852$

(6) $\log\left(\frac{B'}{A'}\right) = -1.592 \log\left(\frac{B''}{A''}\right) - 1.212$

(7) $\log\left(\frac{B'}{A'}\right) = -0.789 \log\left(\frac{B''}{A''}\right) - 0.400$

(8) $\log\left(\frac{B'}{A'}\right) = -0.890 \log\left(\frac{B''}{A''}\right) - 0.444$

(9) $\log\left(\frac{B'}{A'}\right) = -4.032 \log\left(\frac{B''}{A''}\right) - 2.348$

(10) $\log\left(\frac{B'}{A'}\right) = -1.294 \log\left(\frac{B''}{A''}\right) - 0.552$

(11) $\log\left(\frac{B'}{A'}\right) = -0.905 \log\left(\frac{B''}{A''}\right) - 0.404$

In the above equations A′ and B′ refer to percent weight of A and B components in the A in B phase, and A″ and B″ to percent weight of the two components in the B in A phase.

High Purity Natural Gas by the Glycol-Amine Process

W. F. CHAPIN, Process Engineer,
The Fluor Corporation, Ltd.

THE glycol-amine process was first developed and used for cases where simultaneous acid gas removal and dehydration of natural gas were desired. But because of the advantageous properties of the solution employed, this process is becoming increasingly important in use as a method of removing acid gas only, where no dehydration is needed. This is especially true of the cases where extremely high purities are required for the treated gas. By use of the glycol-amine process natural gas may be purified readily to the extent that the treated gas will contain less than 0.25 grains of H_2S per 100 standard cubic feet, this content being less than 0.0004 mol percent of H_2S in the gas. Even higher purities than this may be reached economically with the glycol-amine process.

The removal of acidic gases from other gases by the use of an ethanolamine solution is a well-known process. The original investigations conducted, instigated by the need for a method of commercially removing carbon dioxide from helium, have proved the basis for the installation of a great number of plants, almost an industry in itself.

Although the original work concerned the use of several classes of possible acid gas-absorbing agents, the ethanolamines, particularly monoethanolamine and diethanolamine, are those which have proved economically successful in industry. Because of its predominate use, discussion here will be limited to monoethanolamine. At the same time acidic gases will be restricted to those normally encountered in natural gases, carbon dioxide and hydrogen sulfide.

Improvements have been made, naturally, but the principles disclosed by the original investigations[1] remain as the foundation. Aqueous solutions of the ethanolamines are able to absorb CO_2 and H_2S at essentially atmospheric temperatures. When the solutions containing the absorbed acidic constituents are elevated to their boiling points, the acidic components are expelled from the solution. Such properties make for a simple cyclic process.

Equilibrium of Solutions

Mason and Dodge[2] have provided data on the equilibrium of CO_2 and ethanolamine solutions. Similar data for H_2S have been published by Riegger, Tartar and Lingafelter.[3] Many other contributors have added to the fund of data which make it possible to transpose basic principles into plant design.

The many cases where natural gas was treated for purification and then contacted with diethylene glycol to obtain dehydration to prevent hydrate formation during transmission of the gas led to work by Hutchinson resulting in an additional gas-treating process. The Hutchinson patent[4] discloses a process for combined acid gas removal and dehydration wherein the ethanolamine and diethylene glycol are included in the same solution. This permits one-stage treatment of a gas, where both results are necessary, rather than a two-stage setup.

However, the combination process does not necessarily always prove to be the economic choice where both acid gas removal and dehydration are required. In many instances a purification plant followed by diethylene glycol solution treatment is the cheaper alternate. The choice is dependent upon the size of the required plant and on the treating requirements.

The recent advent of high purity requirements for treated natural gas has brought the combination glycol-amine process to new industrial importance. It is the leading existing process that will meet economically some of the more stringent purities needed in treated gases. In particular, extremely high purities are required in many instances regarding the H_2S content of a gas. In certain catalytic gas processes even fractional parts of 1 grain of H_2S per 100 cubic feet of gas are sufficient to poison the catalyst employed. Many areas specify gas for domestic use containing not more than 0.25 grains of H_2S per 100 cubic feet. In addition, there are cases where a gas will be subjected to extremely low temperatures, as in some low-temperature fractionation processes, in which event even very small amounts of CO_2 could freeze and plug the equipment.

Typical Flow

Figure 1 shows the typical flow of a glycol-amine gas-treating plant. The sour gas is introduced at the bottom of the absorbing column, the contactor. The gas passes up through the bubble trays in the column where it is thoroughly contacted by the glycol-amine solution which enters at the top of the column. The residue gas, free of CO_2 and H_2S and dehydrated if desired, leaves the top of the column. The rich glycol-amine solution, containing the acid gases, leaves the bottom of the contactor and passes through conventional heat exchangers, where heat is exchanged with the hot lean solution. The heated rich glycol-amine solution then is introduced into the regenerating column, the still. The solution passes down through the still where it is contacted with the vapors rising up through the column, thus heating the solution further and stripping out the acid gases. The solution leaving the bottom tray is boiled in a reboiler to provide the stripping vapor in the column. The overhead steam and acid gas stream from the still passes through a water-vapor condenser, and the resultant mixture is separated in an accumulator, the acid gases leaving the top of the vessel and the condensate

being pumped to the still as reflux. The regenerated lean glycol-amine solution leaves the bottom of the still, passes through the exchangers and is pumped through coolers back to the top of the contactor, thus completing the cycle.

Regeneration of Solution

An expedient that has come into practice in the utilization of aqueous monoethanolamine solutions is the provision for pressure regeneration of the solution. The regenerating column is maintained under greater than atmospheric pressures ranging up to 50 pounds gauge. The higher pressure elevates the boiling point of the solution and permits more complete regeneration of the treating solution as far as CO_2 is concerned. However, the increased pressure with a corresponding increase in temperature does not improve the stripping of H_2S from the solution—rather, it is hindered.

In the case of CO_2, the dissociation of the monoethanolamine carbonate increases rapidly enough with temperature to overcome the adverse effects of increased pressure on stripping. Such is not the case with H_2S. The benefits of increased temperature are not sufficient to offset the undesirable effects of increased pressure on stripping, and the solution can be more completely stripped of H_2S at atmospheric pressure than at elevated pressures.

Such a situation may be helped in some instances by employing combinations of two-stage regenerating set-ups, stripping part of the solution at essentially atmospheric pressure to obtain H_2S stripping, and subjecting the bulk of the solution to pressure regeneration to effect more complete CO_2 stripping.

Under any pressure in the regenerating column, more complete stripping of both CO_2 and H_2S may be accomplished by more severe boiling of the solution. Increasing the quantity of stripping vapor decreases the partial pressure of acid gas above the solution and thus reduces the equilibrium amount of acid gas remaining in the solution. However, such an alternate would rarely prove an economical method of obtaining more complete removal of acid gas from the solution as the increase in required heating and cooling loads for the plant would be considerable.

Again considering regeneration at an elevated pressure, the total amount of acid gas remaining in the stripped lean solution is markedly reduced. Although the H_2S content of the regenerated solution would increase somewhat as the CO_2 content decreases when raising the pressure, the actual quantity of H_2S remaining is considerably smaller than that of CO_2. The overall result is a decrease in total acid gas content. This, then, normally would result in a more economical plant as the reduced amount of acid gas remaining in the regenerated solution would reduce the required solution circulation rate of the plant.

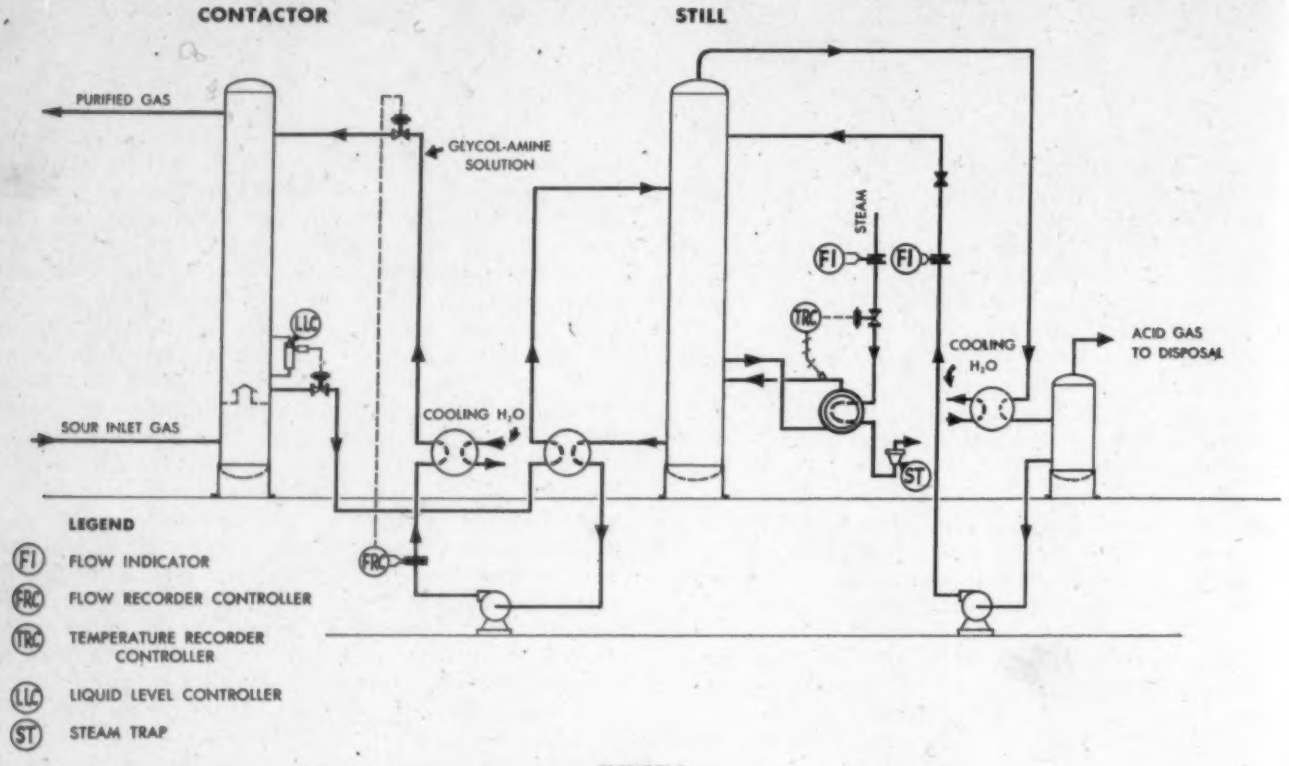


FIGURE 1
Typical flow diagram for a glycol-amine gas-treating plant.

Although increased pressure on the regenerating column allows a reduction in solution circulation, there are cases where the increased quantity of H_2S in the lean solution will prevent meeting a certain purity requirement on the gas being treated.

In the case of the combination glycol-amine process, stripping of the acid gas may be accomplished to a much higher degree. The addition of glycol to the solution raises the boiling point of the solution without necessitating an increase in pressure on the regenerating column. Consequently, the adverse features of increased pressure are not encountered, and both CO_2 and H_2S may be stripped completely from the solution.

Comparative Stripping Results

Figure 2 shows comparative stripping results for CO_2 obtainable with aqueous monoethanolamine and

monoethanolamine glycol solutions. The MEA-H_2O line, showing the effects of pressure regeneration, is based on data presented by Reed and Wood.[5] The

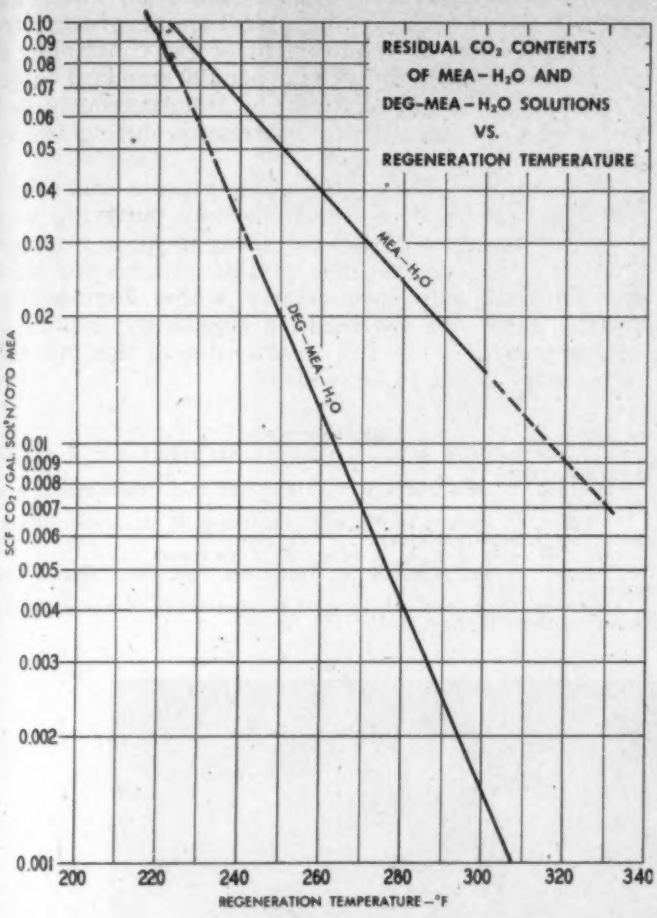


FIGURE 2
Comparative stripping of CO_2 obtainable with aqueous amine and glycol-amine solutions.

glycol-amine data (DEG-MEA-H_2O) are derived from operating plants and a pilot plant. The latter show the effect of varying amounts of diethylene glycol in a glycol-amine-water solution.

The difference in behavior of H_2S with the two solutions is even more pronounced than for CO_2. Although the actual quantity of the residual H_2S is less than that of CO_2 for either solution, the divergence of the MEA-H_2O and DEG-MEA-H_2O lines for residual H_2S content is considerably greater than that shown for CO_2.

It then becomes apparent that an even lower circulation rate is required to accomplish a certain treating job with a glycol-amine solution than with an amine-water solution because of more complete acid gas stripping when reactivating the solution. In addition, it is pertinent that to obtain the stripping of CO_2 from an aqueous monoethanolamine solution by pressure regeneration as shown on Figure 2, it is necessary to boil the solution more severely to generate more stripping vapor in the regenerating column than is required to obtain the stripping shown for glycol-amine solutions. The overall result is then a significant decrease in the cooling water, steam and horsepower requirements for the glycol-amine solution under the MEA-H_2O solution.

The maximum purity obtainable on any gas being treated is a function of the pressure in the acid gas-absorbing column and the amount of acid gas remaining in the stripped lean solution. It then becomes obvious that much higher purities are attainable by the use of a glycol-amine solution than by a monoethanolamine water solution inasmuch as the glycol-amine solution may be stripped much more completely of the acidic constituents, making the residual acid gas content of the stripped solution considerably less. This is particularly important when considering the cases where extremely low H_2S quantities are specified for the treated gas. A difference of but a few grains of H_2S remaining in the regenerated solution can mean the difference in meeting or not meeting a specified gas purity. The fact that glycol-amine solutions can be stripped so readily, particularly of H_2S, has proved one of the major advantages of the glycol-amine process. By utilization of this solution certain treating requirements for residue-gas purity may be met easily that are difficult to obtain economically by using an aqueous monoethanolamine solution.

Although the glycol-amine process was originally developed to accomplish simultaneous acid gas removal and dehydration, its use is not restricted to this application. If no dehydration is needed, the glycol and water contents of the solution may be adjusted to the amounts desired to meet a certain residue-gas purity. Adjusting the concentration of these two components in the solution allows setting the regeneration temperature to obtain the desired degree of acid gas stripping. Thus, if a residue gas containing 1 grain of H_2S per 100 standard cubic feet were desired, a glycol-amine solution containing more water and less glycol would be used than if a purity of 0.15 grains of H_2S per 100 cubic feet were required.

Partial dehydration of the gas being treated is obtained with any glycol content normally employed. However, if more complete dehydration is required, the water content is decreased with a corresponding increase in the glycol content of the solution. If a straight diethylene glycol solution is employed for dehydration alone to the extent usually required for gas transmission, the water content is usually in the order of 5 percent. A glycol-amine solution with the same water concentration dehydrates the gas to a slightly greater degree than the DEG-H_2O solution.

Flexible Process

The ability to adjust the component concentrations of a glycol-amine-water solution to attain necessary treating and dehydration requirements provides a very flexible process. A wide range of specifications for treated-gas purity and water content may be met by the utilization of the glycol-amine process in both one and two-stage arrangements in contacting the gas. The particular case involved might call for single or double stage purification; it might call for a two-stage set-up wherein the gas is purified first and partially dehydrated, being followed by a final dehydration step; or simultaneous purification and dehydration might be the best answer. The economic choice of the possible alternates would depend upon the residue-gas specifications and the size of the required plant.

Typical solution compositions employed in the glycol-amine process may be comprised of from 10 to 30 percent monoethanolamine, 45 to 85 percent diethylene glycol, and 5 to 25 percent water. Table 1 shows data on purities obtained by glycol-amine solutions containing from 10 to 20 percent water. Higher purities than those shown can be reached economi-

cally by using glycol-amine solutions containing less water than indicated above.

Industrial Application

The industrial application of the glycol-amine process is becoming increasingly important. To the best of the writer's knowledge, utilization of this particular process first made it feasible to guarantee a plant to remove H_2S from a gas to the extent that the residue gas would be sweet to the Bureau of Standards' lead acetate test.[6] This, in turn, led to the possibility of treating sour gas and transporting the purified gas to areas short of fuel and having high purity requirements regarding the H_2S content of the gas. An example of this application is the project now under construction to transmit gas from the West Texas-New Mexico fields to Southern California. The sour gas will be purified by the glycol-amine process to meet the California requirement of gas containing a maximum of 0.25 grains of H_2S per 100 standard cubic feet of gas. The gas also will be simultaneously dehydrated to prevent hydrate formation during transmission.

As mentioned, the glycol-amine process was originated as a method of simultaneously purifying and dehydrating a gas. Although this application remains an important one, the use of this process for acid gas removal only, particularly where high-purity treated gases are specified, is constantly assuming new importance. The full contribution of this process to industry is yet to be realized.

TABLE 1

Contactor Pressure psig	INLET GAS		OUTLET GAS	
	H_2S Grains/ 100 Scf	CO_2 Mol. %	H_2S Grains/ 100 Scf.	CO_2 Mol. %
550	126	6.24	0.02	Less than 0.01
550	151	6.00	0.03	Less than 0.01
165	1,168	9.12	0.18	0
165	804	7.54	0.17	0
50	2,090	11.25	0.25	0
50	12,600	7.27	0.70	0
50	12,680	6.49	0.60	0

REFERENCES

[1] Bottoms, R. R., U. S. Patent Reissue 18,958 (1933) of U. S. Patent 1,783,901 (1930).

[2] Mason, J. W., and Dodge, B. F., Trans. Am. Inst. Chem. Engrs., Vol. 32, 27-47 (1936).

[3] Riegger, E., Tartar, H. V., and Lingafelter, E. C., J. Am. Chem. Soc., Vol. 66, 2024-2027 (1944).

[4] Hutchinson, A. J. L., U. S. Patent 2,177,068 (1939).

[5] Reed, R. M., and Wood, W. R., Trans. Am. Inst. Chem. Engrs., Vol. 37, 363-383 (1941).

[6] McBride, R. S., and Edwards, J. D., Bureau of Standards Technologic Paper TP-41.

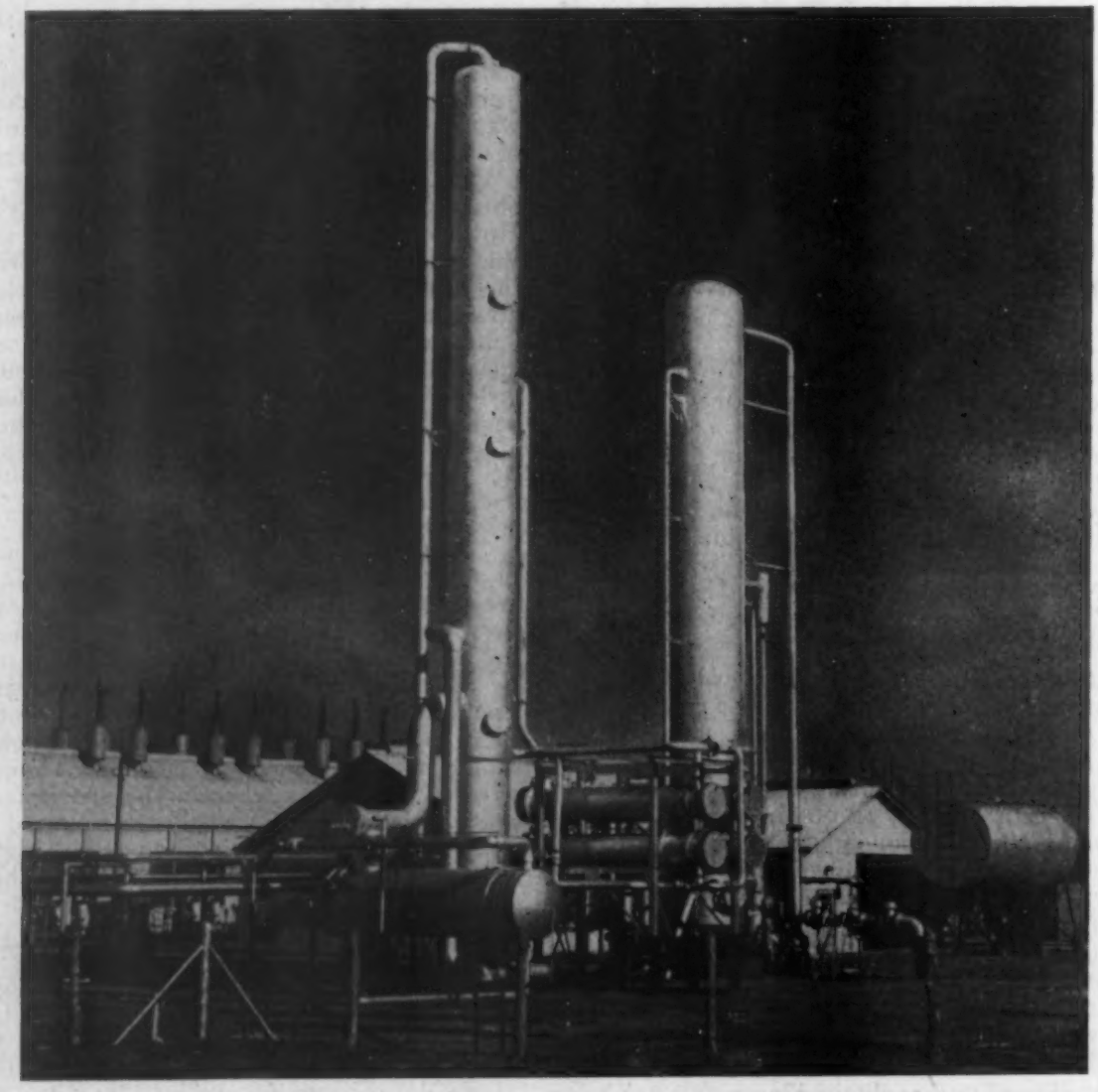
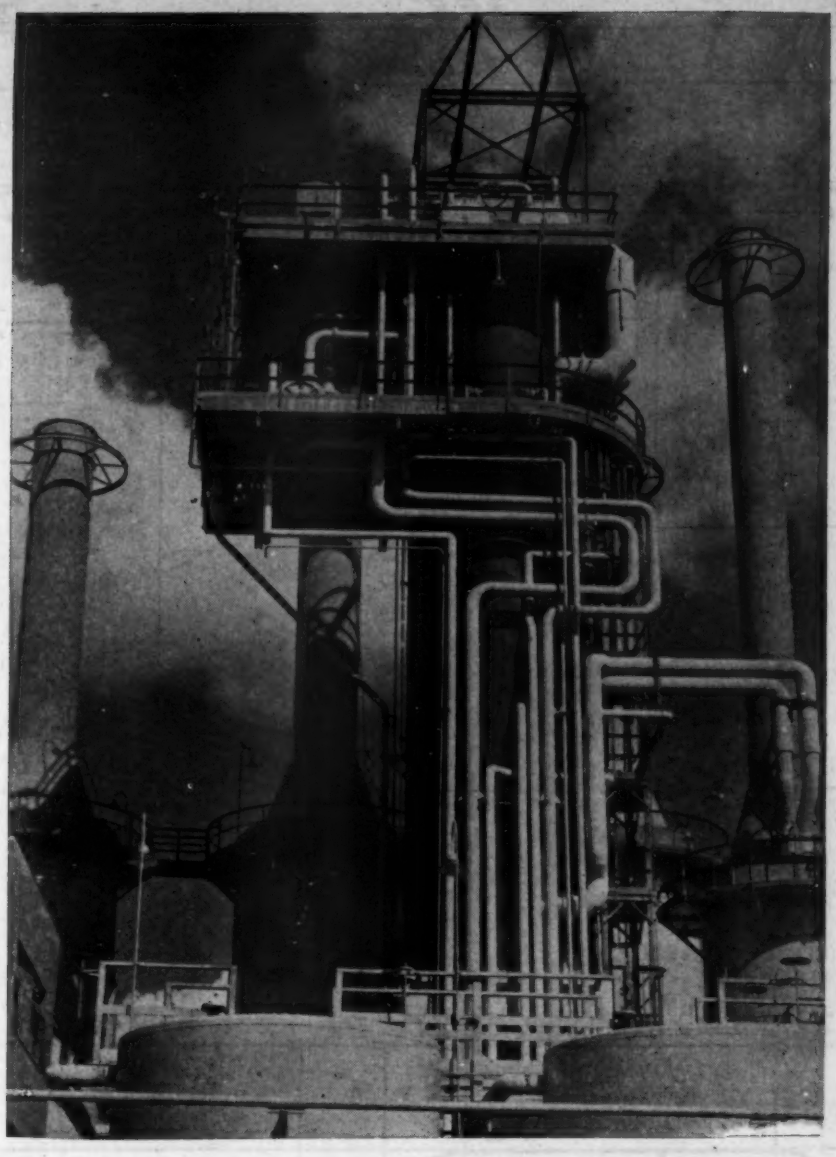


FIGURE 3
Glycol-amine plant for purifying and dehydrating sour natural gas in New Mexico. The still is at the left, contactor at right.



Analysis of Stresses in Unsymmetrical Pipe Frame

JESSE YEAKEL, Structural Engineer

IN AN earlier issue of PETROLEUM REFINER, under the heading "Analysis of Stresses in U-Bend Pipe Frame,"* a method of analysis was presented for determining the stresses caused by expansion of a U-bend in pipes, applying the principle of the column analogy used in structural frames. An illustration of the method was given, using a frame of the simplest type, both legs of the frame being equal in length.

The present article, using the same theory, gives the solutions for two frames somewhat more complicated in outline than the one given in the previous article, to which reference should be made, since certain details are common to both problems. The pipe size is 14" Sch. 30 and the magnitude of the expansion between the two anchor points is $\Delta = .9''$. It is assumed that the frame is secured against rotation at the anchors and is freely supported between these points. The rounded corners form quarter-circles whose arc is 33" long and whose moment of inertia is taken as $1220''^4$. The center of gravity of these quarter-circles is indicated by dots on the figures.

* March, 1947, p. 125.

Example 1

This frame (Figure 1) is the same as the one used in the previous article except that one leg is shorter than the other. The six steps required for a solution are numbered the same as in the earlier article. The force at the anchors and the moments and stresses at various points in the frame are to be found.

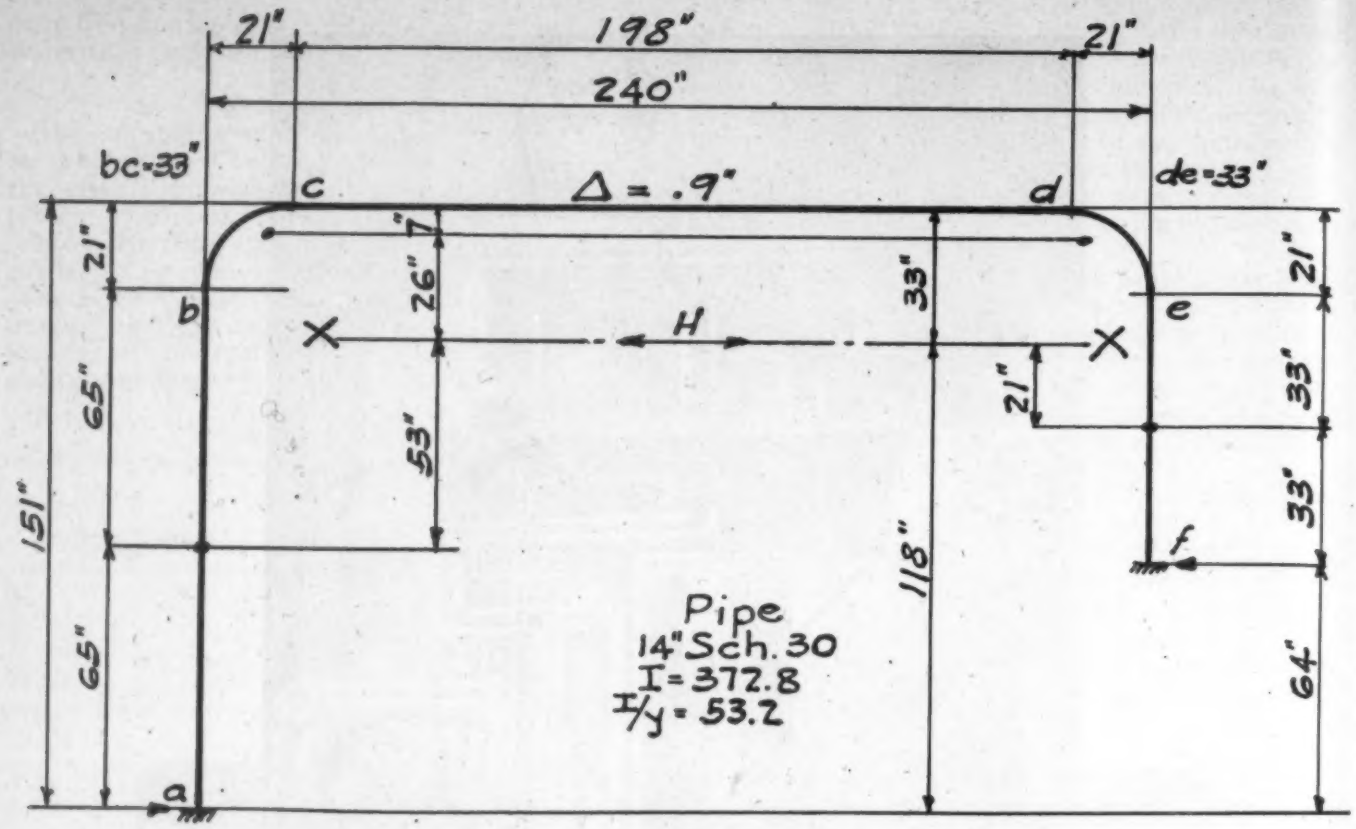


FIGURE 1

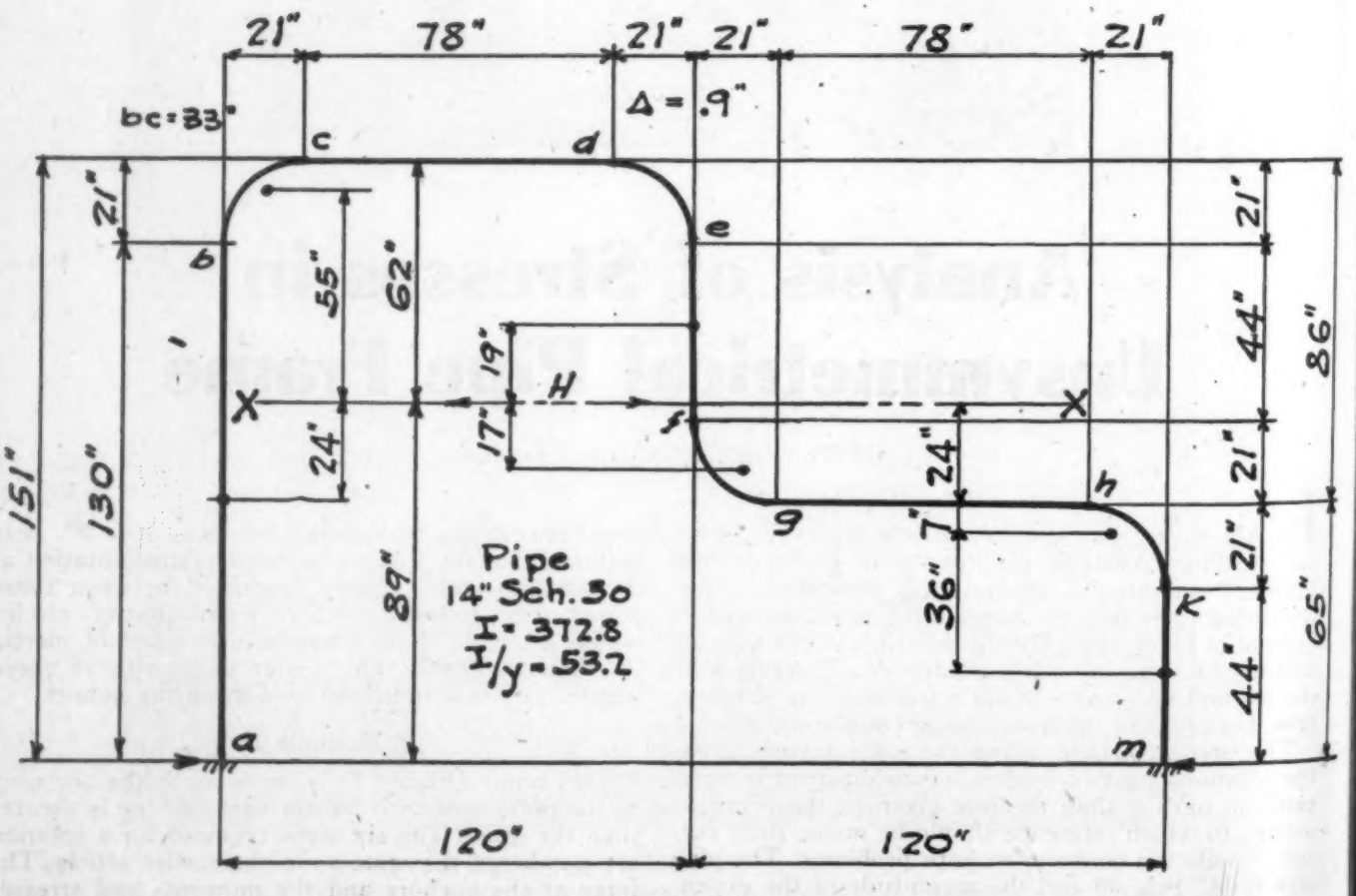


FIGURE 2

(1) *Locate the neutral axis x—x of the frame, taking moments about the base line through a.*

130 × 65 =	8450
66 × 144 =	9500
198 × 151 =	29900
66 × 97 =	6400
460	54250

$$\frac{54250}{460} = 118''$$

(2) *Determine I_{x-x}, the moment of inertia of the frame about the x—x axis.*

$$\frac{1}{12} \times 130^3 = 183170$$
$$130 \times 53^2 = 365170$$
$$\text{(2 corners)} = 2440$$
$$2 \times 33 \times 26^2 = 44620$$
$$198 \times 33^3 = 215620$$
$$\frac{1}{12} \times 66^3 = 23960$$
$$66 \times 21^2 = 29110$$
$$I_{x-x} = 864090$$

(3) *Determine the value of an imaginary force H in the formula $H = \frac{\Delta EI}{I_{x-x}}$, where E is the modulus of elasticity and I is the moment of inertia of the pipe.*

$$H = \frac{.9 \times 30000000 \times 372.8}{864090} = 11{,}650\#$$

(4) *Determine moments at various points in the frame by the formula $M_x = Hy$, where M_x is the moment at a point x whose distance from the x—x axis is y.*

M_a (where $\overline{y}$ is 118) $= 11650 \times 118 = 1{,}374{,}700''\#$
M_b (where $\overline{y}$ is 12) $= 11650 \times 12 = 139{,}800''\#$ (=M_e)
M_e (where $\overline{y}$ is 33) $= 11650 \times 33 = 384{,}450''\#$ (=M_d)
M_f (where y is 54) $= 11650 \times 54 = 629{,}100''\#$

(5) *Determine the force at the anchors by statics.*

$$\frac{M_a + M_b}{130} = \frac{1374700 + 139800}{130} = 11650 \text{ at a.}$$

$$\frac{M_e + M_f}{66} = \frac{139800 + 629100}{66} = 11650 \text{ at f.}$$

This gives a check on the accuracy of the previous figures, as the two forces should be equal to each other and to the imaginary force H.

(6) *Find the flexural stress in the pipe, f_s, at any point by the formula:*

$f_s = \frac{M}{I/y}$ *where* M *is the moment at the point as previously found, and* I/y *is the section modulus of the pipe:*

Stress at a $= \frac{1374700}{53.2} = 25{,}840$ psi

Stress at b $= \frac{139800}{53.2} = 2{,}630$ psi (= stress at e)

Stress at c $= \frac{384450}{53.2} = 7{,}230$ psi (= stress at d)

Stress at f $= \frac{629100}{53.2} = 11{,}830$ psi

Example 2

In example 2 (Figure 2) the outline is complicated still further. The magnitude of the distortion and the size of the pipe are the same as before. The frame is anchored against rotation at points a and m and freely supported elsewhere. The two rounded corners near f and h must be treated separately as their centers of gravity are not equidistant from the x-x axis. The same six steps will give the solution.

(1) *Locate axis x-x, taking moments about line a-m:*

130 × 65 =	8450
66 × 144 =	9500
78 × 151 =	11780
44 × 108 =	4750
33 × 72 =	2380
78 × 65 =	5070
33 × 58 =	1910
44 × 22 =	970
506	44810

$$\frac{44810}{506} = 89''.$$

(2) *Determine the value I_{x-x}:*

$$\frac{1}{12} \times 130^3 = 183330$$
$$130 \times 24^2 = 74880$$
$$2440 \text{ (for 2 corners)}$$
$$66 \times 55^2 = 199650$$
$$78 \times 62^2 = 299830$$
$$\frac{1}{12} \times 44^3 = 7100$$
$$44 \times 19^2 = 15880$$
$$1220 \text{ (for corner f-g)}$$
$$33 \times 17^2 = 9540$$
$$78 \times 24^2 = 44930$$
$$1220 \text{ (for corner h-k)}$$
$$33 \times 31^2 = 31710$$
$$\frac{1}{12} \times 44^3 = 7100$$
$$44 \times 67^2 = 197520$$
$$I_{x-x} = 1076350$$

(3) *Find the imaginary force* H:

$$H = \frac{.9 \times 30000000 \times 372.8}{1076350} = 9350\#$$

(4) *Find the moments at various points in the frame:*

$$M_a = 9350 \times 89 = 832{,}200''\#$$

Moments at any other point can be found by multiplying 9350 by the distance from the x-x axis to the point where the moment is wanted.

(5) The force at a and m should be calculated as previously shown, as a check. In figuring the force at m, note that the moment at k must be subtracted from the moment at m, not added as was done before. This is because both points are on the same side of the neutral axis in this case.

(6) The stresses are found from the moments as shown before.

It was stated at the beginning of this article that the solution given was based on the column analogy method. The question may be asked "Where is the analogy?"

If the frame as drawn in the figures represented the cross-section of a structural column subjected only to a bending moment M about the neutral axis, the stress f_x at right angles to the cross-section at a point at a distance $\overline{y}$ from the neutral axis could be found by the formula $f_x = \frac{M\overline{y}}{I}$, where I is the moment of inertia of the cross-section.

In examples 1 and 2 we found an imaginary force H, multiplied it by a distance $\overline{y}$, and called the result the moment at that point in the frame. If, in the column formula just given, we call f_x the moment in the frame at the point whose distance from the x-x axis is $\overline{y}$, and call M/I the imaginary force H that was found in the frame, it will be apparent that we have used a portion of the general column formula to find the solution of the problem in the frame. The usefulness of the analogy lies in the fact that a simple formula that is well known can be taken as a guide in more complicated calculations.

Physical Chemistry of Lubricating Oils

VI. PHASE EQUILIBRIA

A. BONDI

International Lubricant Corporation,* New Orleans, Louisiana.

NEARLY all refining processes and many of its applications involve or even require the simultaneous presence of lubricating-oil components in more than one phase. It is therefore of considerable interest to review the available data on their phase equilibria, their dependence on the variables of state, and—in variation from usual procedure—the factors determining the rate of equilibrium attainment.

The order of treatment will be: vapor-liquid equilibria and vaporization; liquid-solid, liquid-liquid equilibria and extraction.

VI. 1 Vapor-Liquid Equilibria

The equilibrium constant giving the ratio of the concentration of molecules in the vapor phase to those in the liquid phase at any moment at constant temperature, pressure, and concentration is usually called the vapor pressure of a liquid and expressed in mm mercury column, in Kg/cm², or in dynes/cm². The dependence of the vapor pressure on temperature is (in the low-pressure region of interest for lubricating oils) to a good approximation expressed by the Clausius Clapeyron equation.

$$(1)\qquad \frac{d\ln p}{dT} = \frac{\Delta H_{vap}}{RT^2}$$

where p = vapor pressure, ΔH_{vap} = molar latent heat of vaporization which Lederer[172] showed to be applicable to lubricating oils in the more general form

$$(1a)\qquad \ln\left(\frac{p_B}{p}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T} - \frac{1}{T_B}\right)$$

where: p_B, T_B = pressure and absolute temperature of "boiling point." If log p is plotted versus T_B/T (taking p_B = 760 mm) one can represent the vapor-pressure curves of petroleum fractions by straight lines which were shown by Lederer[172] to intersect the 1mm pressure line at the following T_B/T values:

TABLE 1

$t_B \sim$	170	260	350	450	570° C
T_B/T =	1.52	1.50	1.48	1.46	1.44

Due to the wide boiling range of most lubricating oils one can really not speak of their "boiling point." Without specification as to how this "point" had been determined (whether e.g. as bubble point, or by the vapor temperature at the "first drop," etc.) this constant is meaningless. In the case of vapor-pressure data the entire procedure has to be specified, since it will make quite a difference, whether all of the sample (as in flash vaporization) or only a small portion of it have been vaporized in the course of the determination. An accurate instantaneous boiling (or bubble) point of the sample can probably only be obtained, when so large an amount is being used that the fraction in the vapor phase will be negligible in comparison with the bulk of the liquid.

In contrast with the arbitrary nature of the statically determined vapor-pressure data the dynamic methods seem rather well adapted to describe the vapor tension of lubricating oils in an absolute manner, i.e., as a function of the total amount evaporated. These dynamic methods consist essentially in bubbling a known volume of an inert gas (which at the temperature of operation is essentially insoluble in the oil), such as superheated steam, N_2, CO_2, etc., through the sample at constant temperature and pressure, and collecting and weighing the fractions carried over. The vapor pressure of each fraction is then given by Dalton's law:

$$(2)\qquad P_i = \frac{M_o \cdot P}{\overline{M_i} \cdot r + M_o}$$

when: M_o = Molecular weight of carrier gas, $\overline{M_i}$ = average molecular weight of fraction, r = weight ratio gas/oil, P = total pressure on system. A number of such dynamic methods have been described in the literature[151, 172, 173] the last of which is based on the use of N_2 as carrier. While, as a rule, it will suffice to express the results of these measurements in the form of characterizing vaporization curves, it should be kept in mind that a simple additional measurement, the molecular weight of a few fractions, will permit to estimate, the vapor pressure of the lubricating-oil sample as a function if its state of reduction at one temperature, and with the help of equation (2) subsequently over a wide temperature range. In cases in which vapor-pressure data of more than engineering accuracy are required it should be remembered that equation (1a) assumes ΔH_{vap} to be independent of temperature. Actually

$$(\partial \Delta H_{vap}/\partial T)_p = \Delta C_p,$$

where ΔC_p = difference in specific heat between vapor and liquid. ΔC_p is negative and its order of magnitude can be computed from the accompanying Watson graphs. ΔH_{vap} decreases most sharply in the neighborhood of the critical temperature, at which latter it becomes zero. This temperature region is for most lubricants unapproachable without decomposition (T_c ranging between 400 and 600° C.)[174] use of equation (1a) (especially below 1 atmosphere) should therefore in practice hardly ever lead to large errors.

As the components of lubricating oils are closely related chemically, the partial pressure exerted by each component is given by Raoult's law, such that

$$P = \Sigma c_i p_i^* = \Sigma \bar{p}_i$$

and the vapor concentration of each component in

* Now with Shell Development Company, Emeryville, California.

equilibrium with the oil $N_1 = p_1/P$. The mathematical treatment available for the separation of multicomponent mixtures by distillation[175,176,177,178] is equally as applicable to lubricating oils as to the light oil fractionation for which it had originally been prepared. There is this important difference, however, to be observed: the pressure drop of conventional vacuum-fractionating towers is sufficiently high to affect the total pressure on each tray to a more serious extent than in atmospheric- or higher-pressure operation.

The volatility ration P_A°/P_B° depends on temperature by

$$(3) \qquad \ln (P_A^\circ/P_B^\circ) = -\frac{\Delta H_A - \Delta H_B}{RT}$$

Since—within the same group of compounds—the substance with lower P always has the higher ΔH, we can conclude from equation (3) that P_A°/P_B° increases as the temperature is decreased.[179] The larger P_A°/P_B° the easier the separation of A and B by fractional distillation. Vacuum distillation should therefore not only be advantageous because of the chemical effects of lower temperatures but also because of better separation achievable.

Actually we observe that separation by vacuum distillation (in presently available equipment) is poorer than can be obtained by atmospheric- or somewhat higher-pressure distillation. The cause of this unexpected behavior is to be found among the factors determining mass-transfer and heat exchange rather than in an erroneous derivation of equation (3). The latter just determines the position of the equilibrium between A and B, but cannot predict whether the operating conditions will permit to reach this equilibrium. Unfortunately there are many factors inherent in vacuum distillation which militate against efficient fractionation: at the relatively lower temperature of operation under vacuum the viscosity of the liquid phase is high. Consequently diffusion through the liquid film is slow and not much aided by turbulence, since liquid flow across vacuum tower trays is quite slow. For this reason alone the efficiency of separation may be expected to decrease with a higher than the 0.6 power of fluidity which had been observed in the case of atmospheric distillation of light oils.[180] Much more serious than the resistance to mass—and concurrently heat—transfer in the liquid phase is probably the resistance to mass transfer through the vapor phase. The low mass velocities of the highly attenuated vapors minimize (if not exclude) turbulent flow and the attendant eddy diffusion. Consequently the mass (or heat-transfer) coefficients for the vapor film in vacuum distillation are very much smaller (often by a factor of 50) than at atmospheric pressure.[181] The requirement of extremely low pressure drop throughout the fractionating equipment, in order to benefit from the vacuum at the point where it is needed most—at the entrance of the flashing oil-vapor mixture, excludes increase of mass transfer coefficients by increase in mass velocity. While a few designers have been cognizant of the need for a basically new approach to the engineering of vacuum fractionators[182, 183] much remains to be done before the potentialities of equation (3) with respect to "sharp-cutting" of lube-oil distillates can be exploited to the extent to which many lubricant specifications of the near future might drive.

Lubricating oils also can be vaporized by the Villard effect, i.e., into a high-pressure-gas atmosphere. As the critical temperature of a mixture is additive

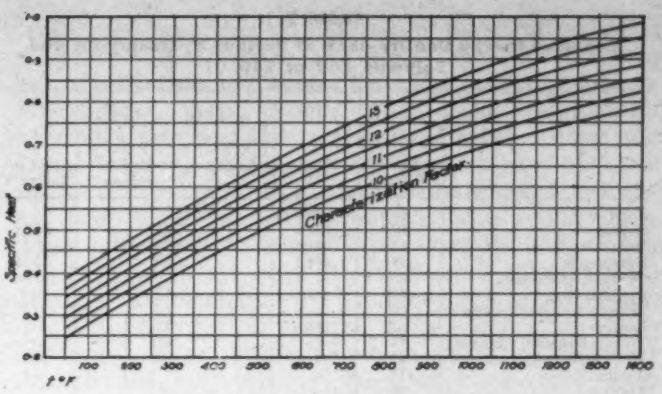


FIGURE 1

Specific heats of petroleum gases at atmospheric pressure. (From Hougen and Watson, Chemical Process Principles, Vol. 1, 1945.)

from the critical temperatures of the components, one should expect that, if the critical temperature of one of the components is quite low, but its partial pressure high, the critical temperature of the mixture could be brought to very low values. This is indeed observed. Crude oil mixed with methane at pressures of about 300 atmospheres will not only vaporize all the low-boiling components but also substantial portions of colored high-boiling fractions which will condense on pressure reduction (retrograde condensation).[184] Lubricating oil has been observed to vaporize completely into natural gas at pressures of about 400 atmospheres (and room temperature) and condense again on pressure reduction. As one may hardly expect any improved lubricants manufacture by this somewhat costly operation these effects are more of the nature of a laboratory curiosity which may, however, be of occasional use in analytical or preparative work, for which reason they have been recorded here.

VI. 2 Solubility

The miscibility of "ideal" liquids follows rather simple laws.[179] The solubility of a solid in a liquid is given by

$$(4) \qquad \ln N_2^\circ = \frac{\Delta H_f}{R}\left(\frac{1}{T_f} - \frac{1}{T}\right)$$

when ΔH_f and T_f = latent heat and temperature of fusion resp. The ideal solubility of two liquids in each other is infinite. Real solutions do not always follow these laws. Paraffin waxes and related solid hydrocarbons in lubricating oils follow the solubility law (4) quite well, as in general hydrocarbons in the lube-oil molecular-weight range give ideal solutions with each other. In many non-hydrocarbons the deviations from (4) and (5) are quite noticeable, as is also the limited miscibility of lubricating oil with many of the common solvents. These deviations, most of which are in the direction of smaller than "ideal" solubility, are ascribed to two causes: Difference in cohesive energy density between solvent and solute, and strongly negative entropy of mixing due to the requirement of a preferred orientation of solvent and solute molecules toward each other in order to minimize the potential energy between them. The cohesive energy density $\Delta E_v/v$ = Energy of vaporization/molar volume had been recognized by Hildebrand[179] as direct measure of the internal pressure of liquids. The energy of interaction between spherical molecules (or those of spherical fields of force) could then be predicted from the difference

$$\left[\left(\frac{\Delta E_{v1}}{v_1}\right)^{1/2} - \left(\frac{\Delta E_{v2}}{v_2}\right)^{1/2}\right]^2.$$

TABLE 2

Cohesive Energy Density ΔE/V of Various Hydrocarbons and Solvents (all at 250°C)

	$\Delta E/V$ Cal/cc.	Terit °C.	$\left[\left(\frac{\Delta E}{V}\right)^{1/2}_{\text{Aniline}} - \left(\frac{\Delta E}{V}\right)^{1/2}_{\text{Hydrocarbon}}\right]^2$	CST in Aniline °C.
Propane	40.5	96.8	18	
Butane	50	193.1	12.6	83.1x
Hexane	55	234.8	10.3	69.1
Hexadecane	59	461.1	8.7	95.1x
9-Octyl-heptadecane	58	..	9.0	111.6x
Cyclohexane	68	281.1	5.6	30.4
Tri(cyclohexyethyl) methane	63	..	7.3	92.1 (!)
Benzene	85	288.6	2.0	X-)
Tri(ethylbenzene) methane	74	..	4.0	X-)
9,2-Phenylethylheptadecane	61	..	7.9	53.1x (!)
Aniline	112			..
Acetone	95			..
Cresol	111			50xx
Nitrobenzene	104			60xx
Furfural	138			..

x Aniline "points".

xx Approximate difference: CST (Aniline/Hydrocarbon)— CST (Solvent/Hydrocarbons.)

The hydrocarbons marked (!) indicate the large specific effect of aromatic rings on the CST, which is not reflected in E/V.

X-) Below freezing point of Aniline.

As is shown in Table 2, the difference in cohesive energy density between solvent and solute can account qualitatively quite well for many observed solubility phenomena, that is the larger this difference, the smaller the miscibility between two compounds. Quantitative prediction of solubility with the help of Hildebrand's formula is, however, restricted to very simple systems for which the basic assumption of no volume change and no excess entropy of mixing is actually realized. Whenever relatively large and anisodiametrical molecules, such as make up the bulk of a lubricating oil, are mixed with small solvent molecules, especially with polar ones, Hildebrand's formula cannot be expected to predict the mutual solubility since it is inconceivable that the entropy of such system should not change very materially upon mixing. The effect of entropy changes upon miscibility is only beginning to be studied in more quantitative terms[186, 187, 188] and presently available theory suffices only to "explain" observed result but is not able to predict solubility data.

In the evaluation of solubility data of petroleum fractions it should be kept in mind that the results obtained depend very much upon the chosen test method. The "synthetic" method in which the temperature of unmixing at a given concentration of lube oil for instance, is determined will result in lower values of solubility than a method in which

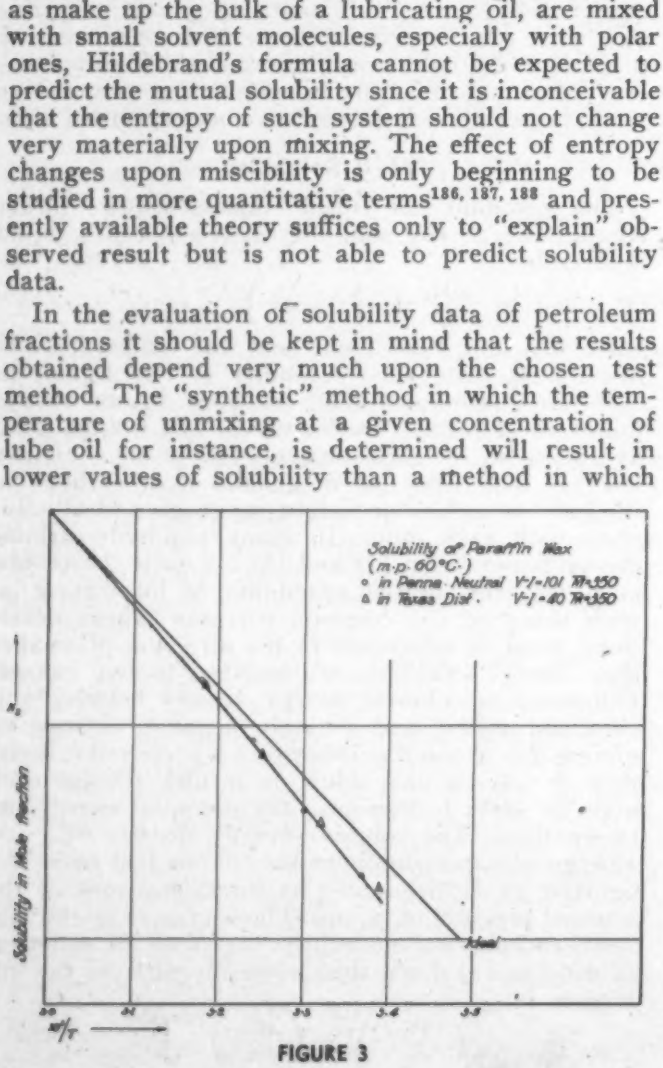


FIGURE 3

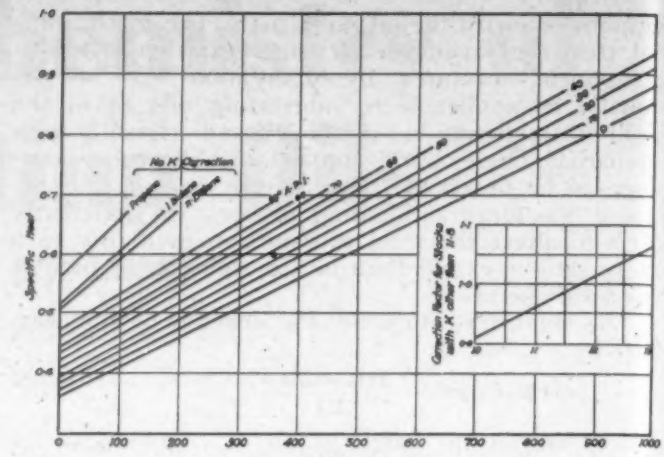


FIGURE 2

Specific heat of liquid oils where K = 11.8 (Mid-Continent stock). For other stocks multiply by conversion factor. (From Hougen & Watson, Chemical Process Principles, Vol. 1, 1943).

just a portion of the fraction goes into solution, since then the more soluble portion accounts for the observed data (which latter will also be a function of the total amount of oil solubilized).

VI. 3 Solubility of Paraffin Wax in Lubricating Oil

The solubility of paraffin wax in lubricating oil is nearly "ideal" as brought out by the solubility curves on Figure 3 which nearly coincide with the "ideal" curve of equation (4). In view of several other investigator's findings which indicate that the solubility of n-paraffins[189] and petroleum-derived paraffin waxes[190] in hydrocarbon solvents is very nearly ideal the behavior of paraffin-wax/lube-oil solutions is not surprising. Direct measurement of the heat of solution of paraffin wax in lubricating oil also showed that the heat of mixing of these two components is quite small. The solubility of paraffin wax in some hydrocarbon solvents and in chlorinated hydrocarbons is occasionally even slightly higher than equation (4) would predict.[191,188] In most other solvents, such as ketones, esters, ethers, alcohols, etc., the paraffin wax is, however less—often very much less—soluble than in lubricating oil. While therefore addition of light hydrocarbons and chlorinated hydrocarbons serves primarily to facilitate dewaxing from a mechanical point of view, ketones and some other oxygenated solvents actually precipitate the wax by substantially reducing its solubility in the oil/solvent

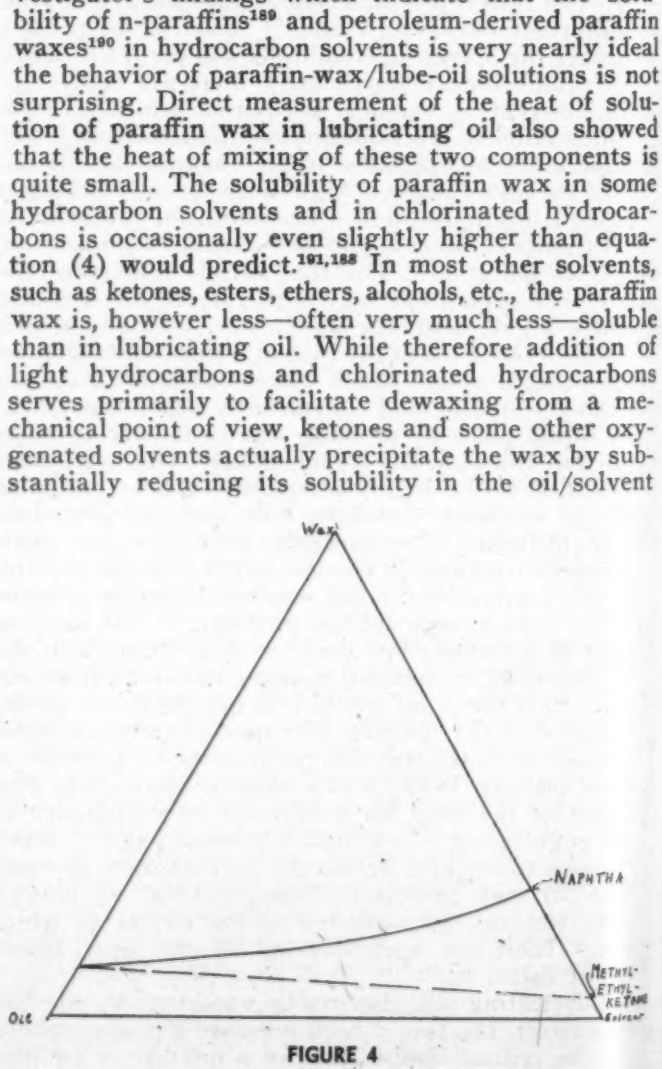


FIGURE 4

TABLE 3

Heat of Solidification Data

SUBSTANCE	Temp. Range of Solidification	Pour Point	ΔH_s Cal/g	$\overline{\Delta H_f}$ Cal/g	ΔH_m Cal/g
1. Paraffinwax	+51 to +48 °C.	+50 °C.	42	....	....
2. 10 percent No. 1 in 500 Pale	+35 to +16 °C.	+28 °C.	4.5	4.2	.3
3. 10 percent in 300 USP	+40 to +15 °C.	+32 °C.	5.0	4.2	.8
4. Penna. Bright Stock	+15 to + 2 °C.	— 2 °C.	1.6	....	....
5. Penna. 150 Neutral	+ 7 to — 8 °C.	— 5 °C.	2.0	....	....
6. Penna. SAE 30	+ 8 to — 7 °C.	— 5 °C.	1.7	....	....
7. No. 6 + .5 percent Paraflow	+ 7 to —10 °C.	—16 °C.	1.7	....	....
8. Waxy 300 Pale	+15 to + 2 °C.	+ 2 °C.	2.4	....	....
9. No. 8 + .5 percent Paraflow	+13 to + 0 °C.	—27 °C.	2.3	....	....

ΔH_s = heat of solidification of mixture.
$\overline{\Delta H_f}$ = heat of fusion of wax portion.
ΔH_m = heat of mixing.

system. Figure 4 presents the solvent effect in a conventional ternary equilibrium diagram.

The nature of the crystallizing substances which precipitate at low temperatures out of lubricating oils and contribute to solidification has yet to be elucidated. The generic term "wax" is often applied to these substances but it appears that they consist mainly of cyclic compounds with long alkyl chains. One can deduce from quantitative dewaxing studies as well as from measurements of the heat of solidification of lubricating oils how large a volume fraction of solid is present at low temperatures. This is in 20° F.-pour-point Pennsylvania neutrals and bright stock about 3 to 10% at 0° F. (Table 3). The low-temperature viscosity effect of added paraffin wax exceeds the effect of the crystallizing materials occurring in lubricating oils by nearly one order of magnitude, Table 4, indicating that there may be a fundamental difference in constitution between these two groups of compounds. One should, however, not draw any definite conclusions from viscosity measurements, since these are greatly influenced by the morphology of the crystal skeleton set up in the oil. The latter is extremely sensitive to impurities. Not only does the crystal-habit of paraffin waxes and related materials change remarkably with relatively small changes in composition,[192] but also the strength of the resulting gel structure is influenced in a decisive manner by the presence of surface-active agents in low concentration. These agents will be adsorbed on the surfaces of the freshly formed wax crystallites and thereby prevent or impair very often the coherence of wax crystals in form of a continuous skeleton. The effectiveness of these adsorbed layers in reducing the mechanical strength of the gel structure depends very much on their chemical composition. The effect of paraflow has been described in Section III of this series. Many other compounds have been reported in the patent literature[193]; but only recently has a systematic study of the effect of various compounds of this class (the so-called pour-point depressants) upon the "yield values" (and its temperature coefficient) of the solidified oils been reported in the literature.[194] An alkylated phenyl phthalate has been found much more effective in reducing the strength (the yield value) of the wax gel of oils than paraflow by this investigation. Multivalent metal soaps and some oxygenated polymers (such as polyacrylic acid esters) have also found use for this purpose. The ability of these agents to prevent the growth of a coherent gel also has been made use of by refiners, who add some of these substances to lube oils previous to dewaxing in order to facilitate the filtration and cake-washing process. Thermal history produces the usual results in the solidifying oil system. Slow cooling results in relatively large crystals which form a coherent, though not very strong, lace work and are quite easily coated by pour depressants, further weakening this lace structure. Rapid chilling produces a vast number of micron-sized crystallites forming a strong gel structure. The combined area of these many small crystals is so large that the usual concentration of pour depressants is not nearly high enough to cover it even with a monomolecular layer. These agents will therefore often be found ineffective against the effects of rapid chilling, unless their concentration is materially increased. The same holds true where a lubricating oil is exposed to repeated chilling and heating cycles.[195] The formation of the above described crystal structures in lubricating oils does not occur instantaneously but proceeds at a definite rate. As is well known, this rate depends largely on the degree of supersaturation of the solution, and for each of its components, the rate of crystal nucleus formation as well as the rate of crystal growth, shows a maximum some degrees below the equilibrium temperature. The presence of a wide variety of crystallizable substances each of which exists in a different degree of supersaturation at any one temperature superimposes the distribution curve of these substances upon the crystallization rate vs. temperature curve[196] and complicates the picture so hopelessly that it becomes hardly worthwhile to investigate these rate phenomena more closely. The dependence of the pour point of paraffinaceous oils on the preheating temperature—their passing through a maximum—is the only available indication of the applicability of the rules of the kinetics of phase transition to solidifying lubricating oils, as is the well known dependence of the "cloud" point on the length of time a sample is kept at that temperature, visible crystals starting to appear sometimes only after several days of freezing.

TABLE 4

Low-Temperature Viscosity of Wax Solutions

SUBSTANCE	VISCOSITY AT °C.				
	0	—5	—10	—15	—20
1. USP White Oil 300	11.6	18.6	33.1	59	192 poise
2. No. 1 + .5 percent Parrafin Wax	24.6	64	124	320	1340 poise
3. No. 2 + .5 percent Paraflow	14.4	24.4	46	87	160 poise
4. No. 1 + .5 percent Osokerite	38	64	205	630	3500 poise
5. No. 4 + .5 percent Paraflow	16.2	28	58	110	227 poise
6. No. 1 + 10 percent Vaseline	16.6	29.2	54.7	93	200 poise
7. No. 1 + 5 percent Cylinder Stock	13.6	26.3	52.1	100	203 poise
8. No. 7 + .5 percent Paraflow	13.3	22.3	38.6	79	156 poise

Solid fats (glycerides) and the higher fatty acids as well as most of their esters have been found to form ideal (or very nearly so) solutions in lubricating oils. Their solubility in lube oils can therefore be predicted with reasonable accuracy from equation (4). The same does not seem to apply to elemental sulphur although no data are available to test this. Most other solids will depend in their solubility very much upon the chemical nature of the lubricating-oil fraction at hand, whether it is more aromatic, naphthenic or paraffinic in nature. The solubleizing power of the non-hydrocarbon portions (sulphur-compounds, nitrogen bases, naphthenic acids and "resins") should also not be overlooked whenever lubricating oil is considered as solvent for a specific compound.

VI. 4 Solubility of Lubricating Oils in Liquids

a. Non-Hydrocarbons

It has been mentioned above that "ideal" liquids are completely soluble in each other. Lubricating oils and most liquid hydrocarbons form such "ideal" mix-

tures at ordinary temperatures, i.e., they mix in all proportions. As such mixtures approach the critical temperature of the lighter compound, however, something unexpected starts to happen: a portion—namely the highest-boiling portion—of the lubricating oil is precipitated, and successively lighter portions of the lube oil separate out of the mixture as the critical temperature is approached more and more closely, until finally no lubricating oils is contained in the solution. A short reflection will show that this phenomenon is really not so surprising. We saw above that compounds in order to be miscible must not differ very much in cohesive energy density, which latter was defined as $\Delta E_{vap}/V$. As a liquid approaches the critical temperature ΔE_{vap} decreases quite rapidly while V increases. Consequently $\Delta E/V$ diminishes at a considerable rate in the neighborhood of T_{crit}, becoming equal to zero at T_{crit}. As $\Delta E/V$ of the lubricating oil changes but very little in the same temperature range the difference in internal pressure becomes soon sufficient to cause unmixing. So far this phenomenon has been observed with propane, butane, and pentane as solvents.[197,198] It is employed commercially in the form of propane-deasphalting and deresining. Being non-hydrocarbons, the cohesive energy density of asphalts and resins is sufficiently higher than that of hydrocarbons to permit a relatively clean separation of these compounds from residual lube stocks by the indicated method, provided the operating temperature is carefully controlled. A relatively slight increase in temperature will cause precipitation of the deresined lube stock too. Figure 5. Introduction of a lighter hydrocarbon, such as methane, into a butane solution, e.g., has the same effect as increasing the temperature, for it also reduces the cohesive energy density (in direct proportion to partial pressure of the CH_4) of the solvent. The internal pressure of the solvent can thus be easily controlled. S. V. Pilat[198a] showed, indeed, that successive raising of the partial pressure of methane over the butane solution of a lubricating oil permits an astonishing degree of fractionation of such lube stocks, Table 5.

b. Non-Hydrocarbon Solvents

Many a reader will be surprised to learn that there are hardly enough data available on the solubility of lubricating oil and its components in various solvents to prepare a reasonably complete chapter on this subject, despite the fact that such a chapter ordinarily would be expected to contain the fundamental data for solvent-refining processes. Inasmuch as the latter are not concerned with the total but solely with the partial solubility of lubricating oils, or better their extract and raffinate fractions, the vast majority of data are those of ternary equilibria.

The total-solubility curve of lubricating oils in solvents with which it is not completely miscible at all temperatures are generally of the form indicated on Figure 6. The form of this curve does not differ from that of the majority of partially miscible liquid/liquid systems. It is the more asymmetrical the greater the difference in molecular weight between solvent and oil. The maximum of the curve (corresponding to the critical solution temperature-C.S.T.) is shifted toward lower concentrations of oil with increasing molecular weight of latter reaching 30 percent asymptotically. The portion of the maximum can be predicted with fair accuracy from the theoretically justified formulae of Hildebrand[179] and Guggenheim[199]. The maximum is usually quite flat. The common habit of determining the arbitrary

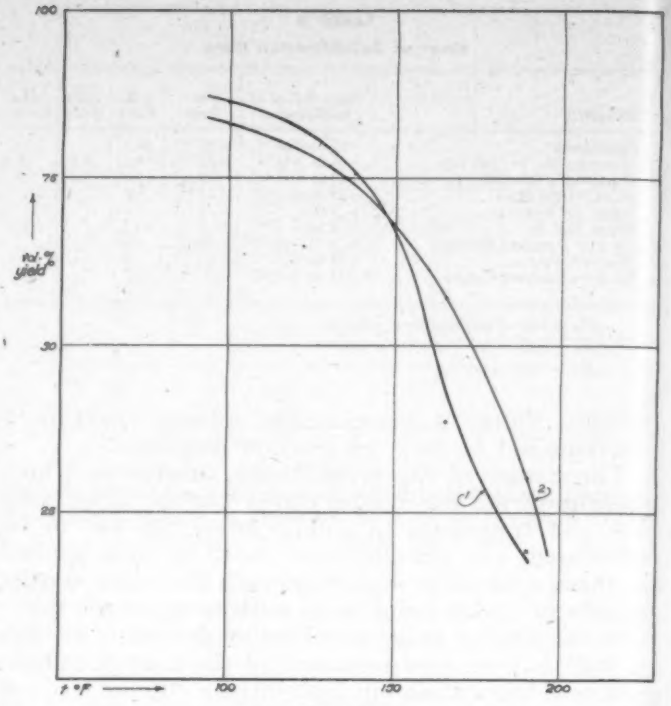


FIGURE 5

Curves showing relationship between temperature and percent yield in propane precipitation of a heavy Mid-Continent residuum for various propane/residuum ratios (from data by Bahlke and coll. (197). Curve 1: Propane-residuum vol. ratio = 4: curve 2: Propane/residuum vol. ratio = 8.

TABLE 5

Pilot-Fractionation of Venezuela Residuum (198a) (involving addition of methane to the solution of oil in a Propane/Butane mixture).

Methane Pressure Atm.	Percent Yield of Precipitate	20 d 4	Properties of Precipitated Fractions: Viscosity (C. S.) At 37.8 °C.	At 50 °C.	At 98.9 °C.	V-I	Pour Point °C.	Flash Point °C.	△H‡ Cal/mole
8.....	49.4	.....	.....	.....	.....	.....	.....	.....	.....
30.....	7.8	1.004	.....	.....	805	.....	.....	.....	.....
40.....	5.9	.9885	.....	.....	378	.....	.....	.....	.....
50.....	6.8	.9665	.....	.....	158	.....	+ 9	293	.....
60.....	4.8	.9535	6300	2110	98	.....	—1.5	286	18,400
70.....	5.6	.9455	4000	1342	72.5	43	— 3	283	18,208
80.....	3.9	.9365	2270	835	52.5	49	— 2	288	16,670
90.....	3.5	.9300	1360	518	39.7	50	—14	264	16,108
100.....	2.9	.9230	817	335	30.8	54	—18	264	14,920
130.....	3.2	.9145	476	203	21.8	50	—18	264	14,216
Residue.	2.0	.906	225	103	13.6	41	—18	264	13,033

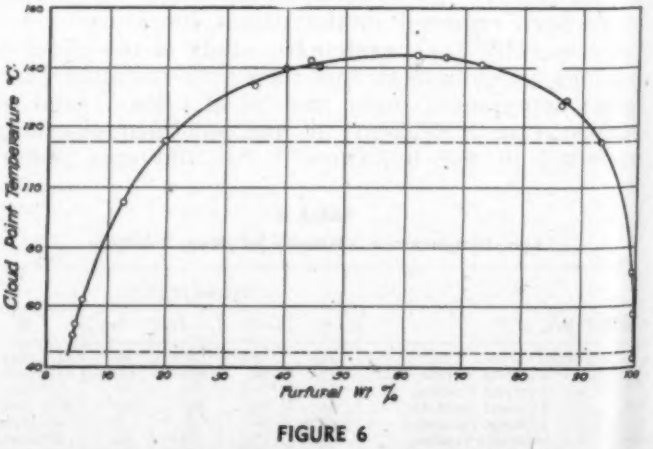


FIGURE 6

Cloud point temperature-composition for Docosane-Furfural system. (From paper by Briggs and Comings (ref. 200)).

miscibility "point" (such as the aniline point) at higher concentrations than correspond to the C.S.T., will therefore usually put these "points" only a few degrees below the C.S.T., but of course rob them of the physical significance of the C.S.T. The solubility data of lubricating oils and related pure hydrocarbons consist usually only in the C.S.T. or mixing point with aniline, nitrobenzene, etc., but hardly ever contain the full solubility curve as given on Figure 6. This is most regrettable since—in the reviewer's experience—the curves of two oils or hydrocarbons of different composition but equal C.S.T. in a given solvent may differ considerably in detail, though not in general pattern. The slope of these curves depends on both, the energy and the entropy of mixing, two highly "individualistic" constants! The C.S.T. depends upon the ratio of the average molecule size of the oil to that of the solvent and the interaction energy w of the two according to Guggenheim's[199] equation

(6)

$$\text{C.S.T. } (°K) = 2w/k \ln \left[\tfrac{1}{2}\{1 + ab + \sqrt{[(a^2-1)(b^2-1)]}\}\right],$$

where: $a \sim n_A/(n_A-2)$, $b \sim n_B/(n_B-2)$, $n_i \sim$ number of "sites" occupied by each molecule.

The exact form of the solubility curve is therefore not sufficiently defined by the C.S.T. alone or in combination with the molecular weight (or volume) of the components. The principles of solvent extraction could be attacked in a much more profitable manner if more were known about the nature of these solubility curves. Data have been forthcoming only so sporadically[200] that there are too few to test any of the theories of solubility of large molecules.

At temperatures about 15 to 20° C. below the C.S.T. and lower the total solubility of lubricating oils or related hydrocarbons in partially miscible solvents follows the simple law

(7) $$(\partial \ln N_2/\partial 1/T)_P = \Delta E_m/R$$

meaning that log N_2 vs. 1/T gives a straight line, the slope of which is a measure of the energy of mixing. The latter has usually values ranging from 3 to 10 kcal/mole. As the C.S.T. is approached the slope of the curve changes, becoming steeper and finally almost vertical. The equation (7) obviously breaks down in that region. But a new equation predicting the form of the entire solubility curve has not yet been proposed. From all this it is therefore not surprising to find that the theory of solubility in its present state can account but in a most qualitative way—if at all—for the remarkable differences in solubility among the higher-molecular-weight hydrocarbons, i.e. the latter's dependence on the presence of aromatic C-C bonds, olefinic double bonds and on spatial configurations as has been shown in Section V of this series and on Table 2. The solubleizing effect of aromatic and condensed aromatic nuclei can in many of these cases not be explained from differences in cohesive energy density or the closely related dispersion energy terms, and a much more intimate specific interaction of solvent and aromatic solute has to be postulated from these data than any of the available concepts could provide. As qualitatively the same grading of solubility is shown in a wide variety of solvents, be they of aromatic, heterocyclic, or aliphatic nature, it appears rather improbable that this interaction is of the type of association compound formation. Viscosity measurements show, indeed, a more complete freedom from association in the case of aromatic than of the aliphatic hydrocarbons solutions in the majority of solvents.

TABLE 6

Effect of Temperature on "Selectivity" of Solvent Extraction Results of Batch Reflux Extraction of a Pennsylvania[x] Neutral Stock with Acetone[x]

(Apparatus similar to that described by Cannon and Fenske, Ind. Eng. Chem. 28, 1035, 1936.)

RUN NO.	Original Oil	5-1	7-2
Temp. of Extraction, °C.	.....	25	17
Solvent Rate, liters/hr.	.....	1.5	1.5
Raffinate:			
Weight percent yield	.....	85	84
Visc. at 210 °F., cst.	5.92	5.80	5.76
S.U.S. [a]	44.8	44.4	44.3
Visc. at 100 °F., cst.	40.31	37.58	36.56
S.U.S. [a]	187.7	175.1	170.4
Viscosity Index [b]	99	106	110
Extract:			
Weight percent yield	.....	15	16
Visc. at 210 °F., cst.	.....	7.43	7.63
S.U.S. [a]	.....	49.5	50.2
Visc. at 100 °F., cst.	.....	78.04	84.94
S.U.S. [a]	.....	360	392
Viscosity Index [b]	.....	36	27

[a] Conversion from measured centistokes by relation in Ind. Eng. Chem. 27, 82 (1935).
[b] Calculated from relation given in Ind. Eng. Chem. 27, 1441 (1935).
[x] Private communication from R. E. Fersh.

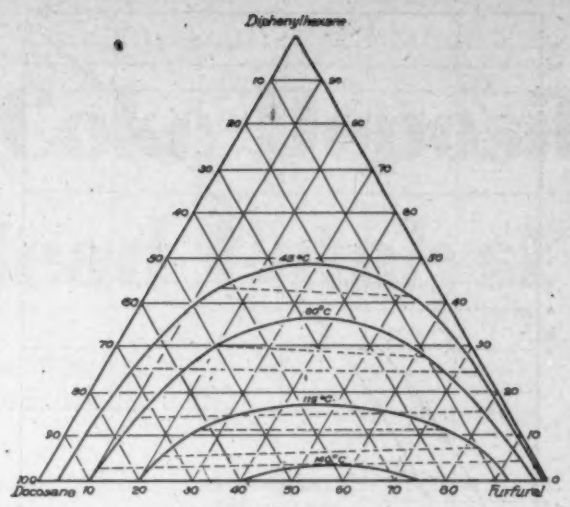


FIGURE 7

Binodal curves and tie lines for the system Cocosane-Diphenyl-hexane-Furfural at several temperatures, indicating the decrease in achievable selectivity with increasing temperature and extraction. (From paper by Briggs and Comings (ref. 200).

The ternay system Raffinate-Extract-Solvent has been studied experimentally over a wide range of solvents and temperatures.[201] It is beyond the scope of this paper to deal with this subject, especially in view of the fact that physical chemistry has not been able to make important contributions to the field of solvent extraction. The equilibrium concentration of the various key components in the coexistent liquid phases as a function of the method of extraction—have been predicted by means of formal mathematical treatment without the use of any specific physical concepts. But that holds true only for isothermal systems. The prediction of the effect of temperature on the ternary equilibrium is still a purely physicochemical problem. To a first approximation it seems reasonable to apply equation (3) to this problem, replacing the quotient $P_A°/P_B°$ by the ratio of the solubilities N_A/N_B and the latent heats by the respective heats of mixing. One would expect then that the quotient N_A/N_B, that means the "selectivity," increases with decreasing temperature. This prediction is brought out by Figure 5 and Table 6.

VI. 5 Solubility of Liquids in Lubricating Oil

Among the solubilities of other liquids in lubricating oil the solubility of water occupies an important

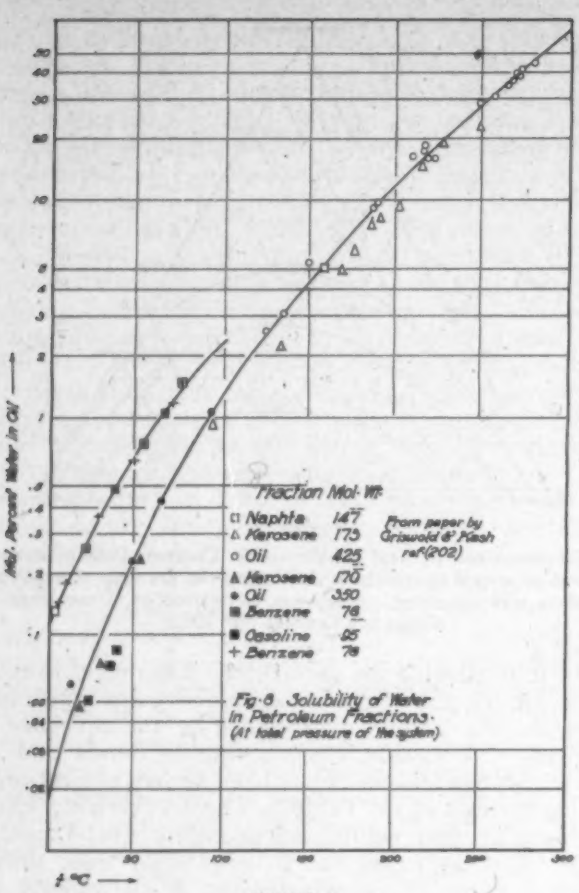


FIGURE 8

Solubility of water in petroleum fractions (at total pressure of system).

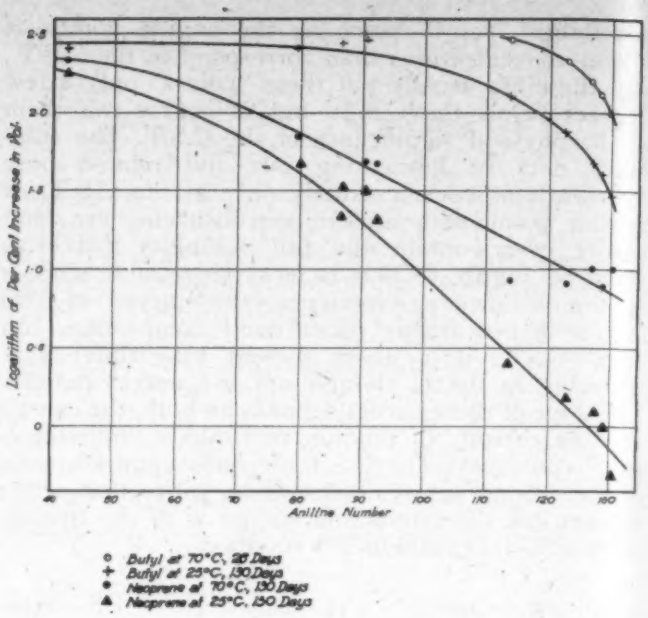

Logarithm of Per Cent Increase in Vol.
Aniline Number
Butyl at 70°C, 26 Days
Butyl at 25°C, 130 Days
Neoprene at 70°C, 130 Days
Neoprene at 25°C, 130 Days

FIGURE 9

place because of the recurrent need for this data in refinery operations. Griswold and Kasch[202] found that —on mole-percent basis—the solubility of water at the total pressure of the system is practically the same for all petroleum fractions over the temperature range 0 to 300° C. (Figure 8). For the solubility of lubricating oil in water no simple relationship could yet be found. At boiling-water temperature the latter is about 10^{-5} to 10^{-4} mole percent oil, depending on the molecular weight of the oil. Closely related to solubility phenomena is the swelling of rubber and synthetic elastomers in lubricating oil. Figure 9 shows the close relationship between aniline point of oil and swelling tendency of elastomer in same.[203] This relationship does not hold when the lubricating oil contains high polymeric additives, such as poly-iso-butylene V-I improvers due to the deswelling effect of dissolved high-polymers. [204, 205] Elastomers which are exposed to such solutions swell substantially less than in the polymer-free oil.

BIBLIOGRAPHY

[173] E. L. Lederer, Petroleum Z.
[174] G. E. Barker et al., ASTM-Bull. No. 139, 25 (1946).
[175] R. L. Smith and K. M. Watson, Ind. Eng. Chem. 29, 1408 (1937).
[176] W. L. Nelson, Petroleum Refinery Engineering, McGraw Hill 1941.
[176] Bell, American Petroleum Refinery, 1945.
[177] C. D. Shiab, Petroleum Refiner 21, 261 (1942).
[178] W. C. Edmister, Trans. A. I. Ch. E. 42, 15 (1946).
[179] J. H. Hildebrand, Solubility of Non-Electrolytes, Reinhold 1936.
[180] Drickamer and Bradford, Trans. A. I. Ch. E. 39, 319 (1943).
[181] G. T. Atkins, Jr., Oil Gas J. 41, No. 46, 180 (1943).
[182] Schaffner, Bowman and Coull, Nat. Petr. News 35, R-272 (1943).
[183] H. F. Willkie and J. H. Prochaska, Fundamentals of Distillery Practice, Louisville 1943, p. 119.
[184] Katz and Hachmuth, Ind. Eng. Chem. 29, 1072 (1937).
[185] A. J. Staverman, Rec. trav. chim. 60, 76, 640 (1941).
[186] H. S. Frank, J. Chem. Phys. 13, 507 (1945).
[187] A. Bondi, J. Phys. Chem. (to be published).
[188] A. W. Mazee, T.O.M. Reel 79, p. 2504.
[189] Weber and Dunlap, Ind. Eng. Chem. 20, 383 (1928).
[190] Ralston, Hoerr, and Crews, J. Org. Chem. 9, 319 (1944).
[191] S. W. Ferris and H. C. Cowles, Ind. Eng. Chem. 37, 1054 (1945).
[192] J. H. Byers, Nat. Petr. News 28, Dec. 2 (1936), 29, R-359 (1937).
[193] V. S. Ramaya, in Viscosity of Liquids and Colloidal Solution, Moscow, 1944, Vol. 2, p. 178.
[194] J. J. Giammaria, ASTM Bull. 138, 44 (Jan., 1946).
[195] A. Bondi, Petroleum Z. 33, 14 (1937).
[196] Bray, Swift, and Carr, Proc. API, 14, III, 96 (1933).
[197] W. H. Bahlke and Coll., Nat. Petr. News 29, R-114 (1937).
[198a] S. V. Pilat and M. Goldewies, Congr. Mond. Petr., Paris, 1937.
[199] A. E. Guggenheim, Proc. Roy. Soc. (London) 183A, 213 (1945).
[200] Briggs and Comings, Ind. Eng. Chem. 35, 411 (1943).
[201] See reviews by A. Klinkenberg, Compt. rend. Zieme Congr. Mond. Petr., Paris, 1937; T. G. Hunter in Science of Petroleum, London, 1938, p. 1818 seq.
[202] I. Griswold and J. E. Kasch, Ind. Eng. Chem. 34, 804 (1942).
[203] A. C. Hanson, Ind. Eng. Chem. 34, 1326 (1942).
[204] P. O. Powers and H. A. Robinson, Ind. Eng. Chem. 34, 614 (1942).
[205] R. F. Boyer, J. Chem. Phys. 13, 363 (1945).

Combustion of Coke Deposit On Synthetic Bead Catalyst

W. A. HAGERBAUMER and RUSSELL LEE
Socony-Vacuum Oil Company, Inc.

THE stagewise combustion of coke deposits from flowing beds of cracking catalysts has been investigated. The major process variables affecting the rate of carbon burning were found to be oxygen concentration, temperature and the concentration and distribution of carbon on the catalyst particles. The effects of these variables have been correlated by graphical methods. Data for regenerating bead catalyst are presented and discussed.

The correlated data have been applied successfully in designing kilns for commercial TCC units. The construction and operating features of TCC kilns are described.

This paper was presented before the Fuels Division of the American Society of Mechanical Engineers, Spring Meeting, Tulsa, Oklahoma, March 2-5, 1947.

THE Thermofor Catalytic Cracking (TCC) process has been described and its overall development discussed in several publications.[1,2,3,4] In developing this process, as is frequently the case, experimental work was necessary on many of its component operations to acquire adequate specialized information for designing practical, operable industrial installations. The study of one of these operations, the continuous combustion of coke from flowing beds of catalyst, is described in this paper. This operation is particularly interesting because it is relatively new and has received little attention in the literature.

A TCC unit consists essentially of a reactor, in which the petroleum charge stock is contacted with the catalyst, and a kiln in which the catalyst is revivified by burning off the coke deposited on the catalyst during the cracking reaction. The catalyst flows through both of these vessels as a substantially compact mass and is transferred continuously between them by elevators. Figure 1 is a simplified flow diagram of the process.

The process requirements of the reactor establish the design basis of the kiln. Thus, for optimum cracking results, volumetric ratios of catalyst to charge oil from 1.5 to 3.5 are required; catalyst enters the reactor at temperatures ranging from 850 to 1050° F. and bearing less than 0.5 weight-percent of carbon; catalyst leaves the reactor for the kiln at temperatures of 800 to 950° F. and contains from 2 to 4 weight-percent of carbon. The coke deposit consists of carbon and hydrogen, usually in the proportions of 20 to 1 by weight.

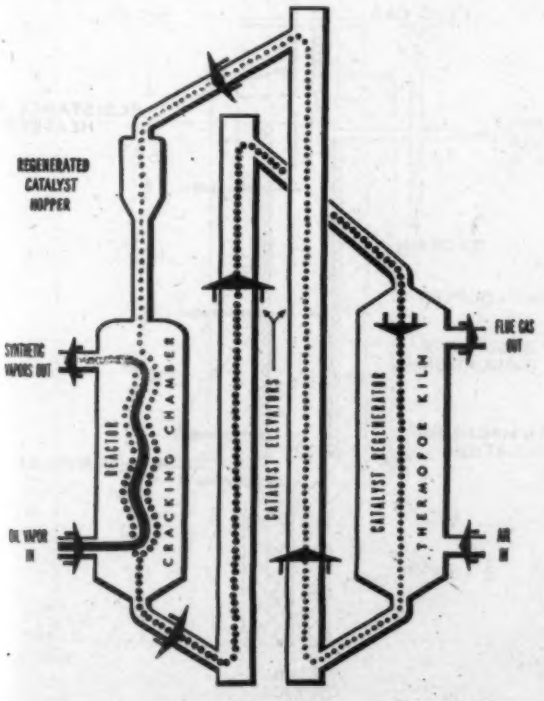


FIGURE 1
Simplified flow diagram of TCC Process

Both clay and synthetic types of catalysts are employed in commercial TCC operations. They are either cylindrical or spherical in shape, mechanically rugged, and average between 0.10- and 0.16-inch in particle size. Engineering studies of catalyst regeneration have been made on all catalysts used or contemplated for use in TCC units. While the basic principles of regeneration are similar for all catalysts, the experimental data reported herein apply specifically to "bead catalysts." A photograph of bead catalyst is provided in Figure 2 and typical physical properties are shown in Table 1.

Multizone Kiln Development

All known cracking catalysts lose activity when exposed to steam and elevated temperatures. The rate of activity decline of a given catalyst is a function of its inherent stability and the relative magnitude of the above deactivating factors. It is evident,

TABLE 1
Physical Properties of Typical Commercial Bead Catalyst

Density, g per c.c:	
Apparent	0.70
Particle	1.10
Substance	2.42
Surface Area, sq. m per g	420
Pore Volume, c.c. per g	0.50
Average Pore Diameter, Å	47
Average Particle Diameter, mm.	3
Particle Size Range, Tyler Screen Scale	4 to 12

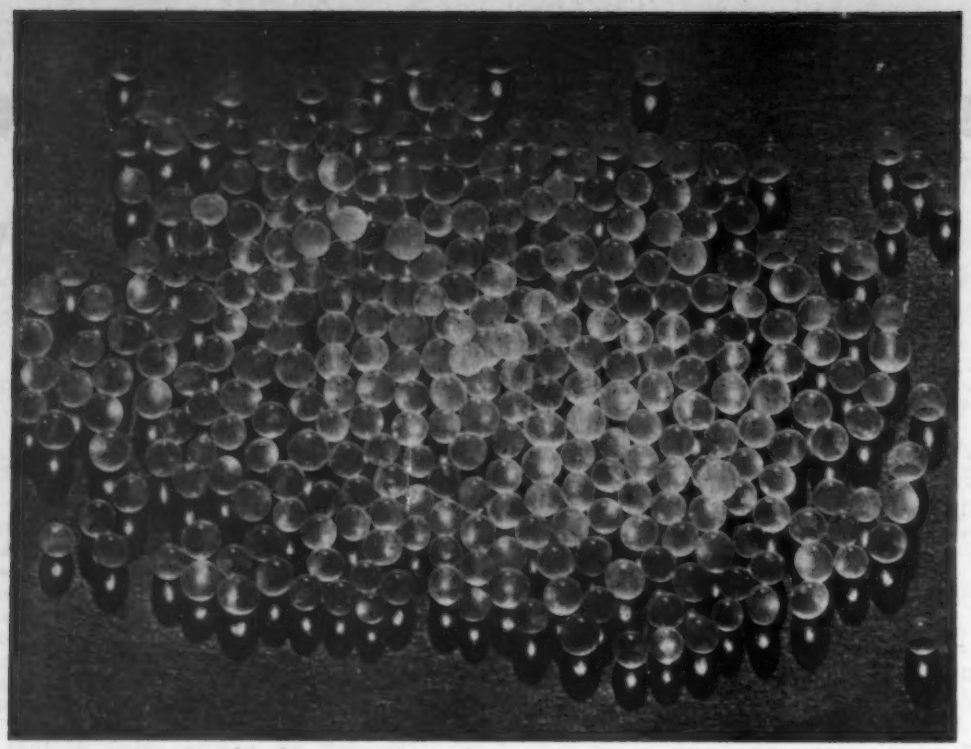


FIGURE 2
Synthetic Bead Catalyst

therefore, that the temperature of the catalyst must be regulated during regeneration to minimize catalyst deactivation.

Although there are several feasible methods for regenerating catalysts in moving-bed systems, process, engineering and economic considerations led to the development of a "multizone" type of kiln for use in the TCC process. In the multizone kiln, coke is burned from the catalyst in a series of zones with temperature control being effected by cooling coils located at various levels in the kiln.

Experimental Procedure

Critical analysis of the problem of burning coke from a flowing bed of catalyst revealed the following main factors for evaluation:

1. *Coke Deposit*
   (a) Initial carbon concentration on the catalyst
   (b) Fraction of the initial carbon remaining on the catalyst
   (c) Relative proportions of carbon and hydrogen
2. *Operating Conditions*
   (a) Temperature
   (b) Air Rate
   (c) Oxygen concentration
   (d) Catalyst volume in burning zone

The type of equipment used to study multistage burning of coke deposits is shown in Figure 3. Coke-bearing catalyst, obtained from a TCC reactor, was passed repeatedly through an adiabatic combustion chamber until substantially all the carbon was burned off. Three combustion chambers, having effective catalyst volumes of 0.13, 0.26 and 0.52 cubic feet, were used. These chambers provided 2.5, 5 and 10 minutes catalyst residence times, respectively, at the catalyst flow rate employed. All were equipped for countercurrent flow of catalyst and air.

In conducting the experimental work the initial carbon concentration was controlled at 1.3, and 6 weight-percent and the atomic ratio of hydrogen to carbon in the coke deposit was varied from 0.3 to 1.0 by altering the operating conditions of the cracking reactor. Study of the effects of kiln operating varia-

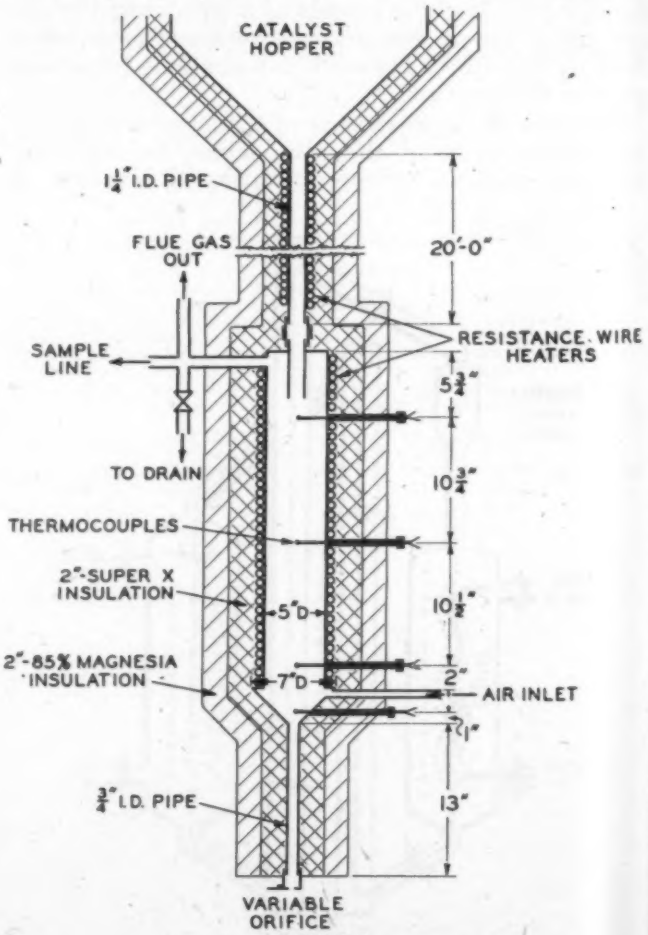


FIGURE 3
Single-zone laboratory kiln.

bles was made using temperatures ranging from 750 to 1150° F. and air rates ranging from one to 16 cubic feet a minute per cubic foot of catalyst volume. All regenerations were conducted at atmospheric pressure, which is substantially the condition in commercial TCC kilns.

Correlation of Data

The laboratory data on the rate of combustion of carbon from flowing beds of bead catalyst at atmospheric pressure were correlated by the relation

$$W = O_m \cdot f_1(T) \cdot f_2(C_o) \cdot f_3\left(\frac{C}{C_o}\right) \qquad (1)$$

where

W = Carbon burning rate, pound carbon per hour per cubic foot of catalyst bed

O_m = Log mean of the oxygen concentrations of the air entering and the flue gas leaving a burning zone, mol fraction

$f_1(T)$ = empirical function of average catalyst temperature, T, °F.

$f_2(C_o)$ = empirical function of initial carbon concentration, C_o, weight %.

$f_3\left(\frac{C}{C_o}\right)$ = empirical function of the fractional carbon concentration

C = average weight % carbon on catalyst in a burning zone.

Preliminary examination of the data revealed that for approximately constant conditions of temperature, initial carbon concentration and fractional carbon concentration, the carbon burning rate, W, varied directly with the log mean oxygen concentration O_m. This direct relationship between W and O_m thus permitted the use of quantity $\frac{W}{O_m}$ in evaluating the effects of the other terms in Equation 1.

A series of successive approximations was made

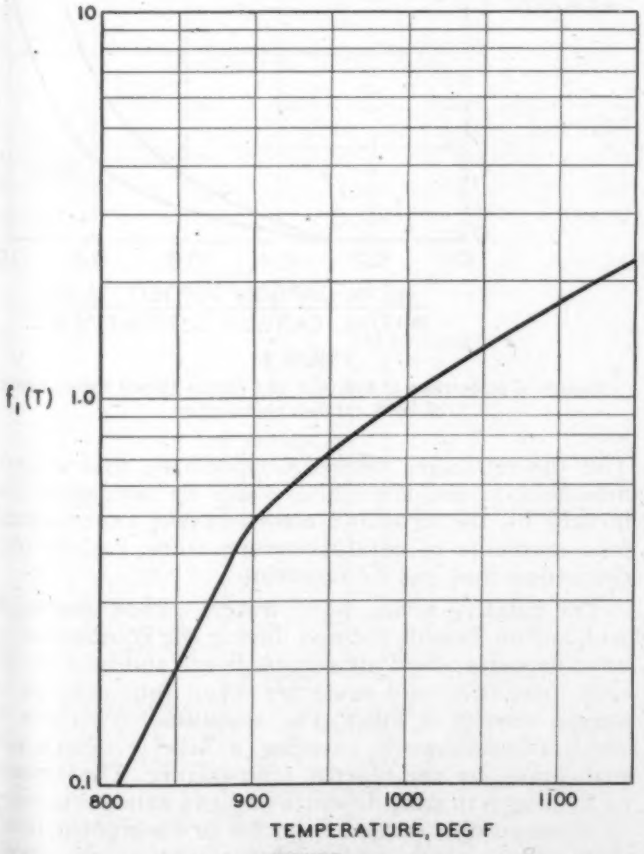


FIGURE 4
Effect of temperature on carbon burning rate.

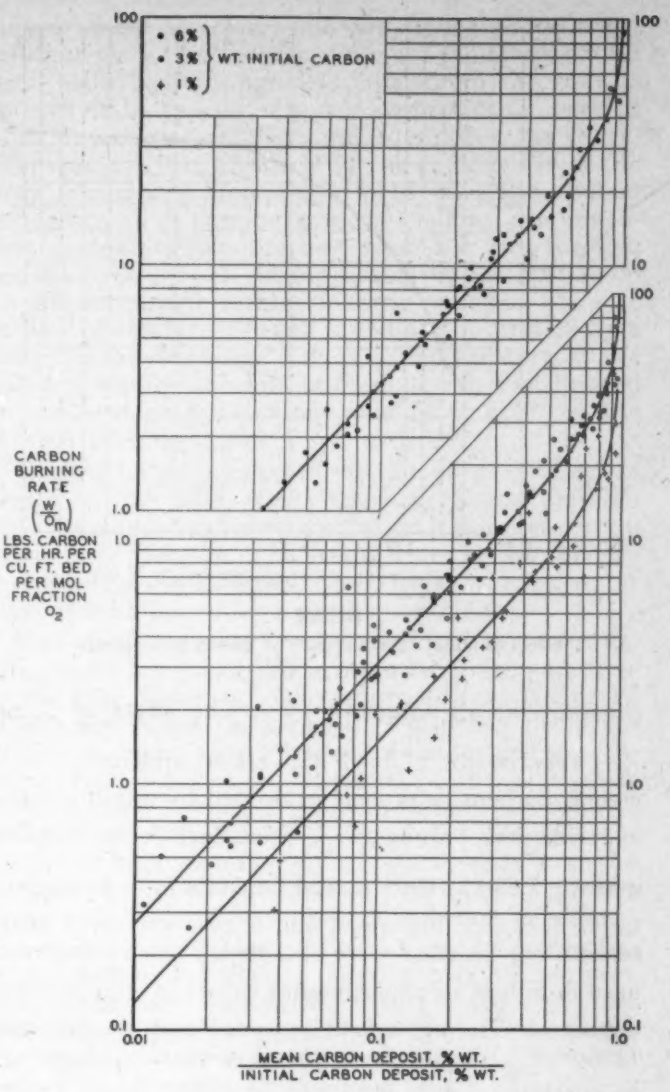


FIGURE 5
Carbon burning rate corrected to 1000° F.

to determine the individual effects of temperature, initial carbon concentration, C_o, and fractional carbon concentration, $\frac{C}{C_o}$, on the quantity $\frac{W}{O_m}$. At the beginning $\frac{W}{O_m}$ was plotted versus $\frac{C}{C_o}$ for each of the three levels of C_o employed in the experimental work, namely 1, 3 and 6 weight-percent. These plots were studied to obtain a preliminary appraisal of the effect of temperature on $\frac{W}{O_m}$. Thus from these data a chart was made by plotting $\frac{W}{O_m}$ versus temperature for constant values of $\frac{C}{C_o}$ and C_o. A series of parallel curves resulted. These curves were resolved into a single curve expressing tentatively relative burning rate as a function of temperature and having arbitrarily a value of unity at 1000° F. The final plot of this function, $f_1(T)$, is presented in Figure 4. A second plot then was made of $\frac{W}{O_m}$ versus $\frac{C}{C_o}$ in which the observed values of $\frac{W}{O_m}$ were corrected to the base temperature of 1000° F., as illustrated in Figure 5. This revealed that the curves for each level of initial carbon concentration, 1, 3 and 6 weight-percent, were parallel and hence the effect of C_o on $\frac{W}{O_m}$ was

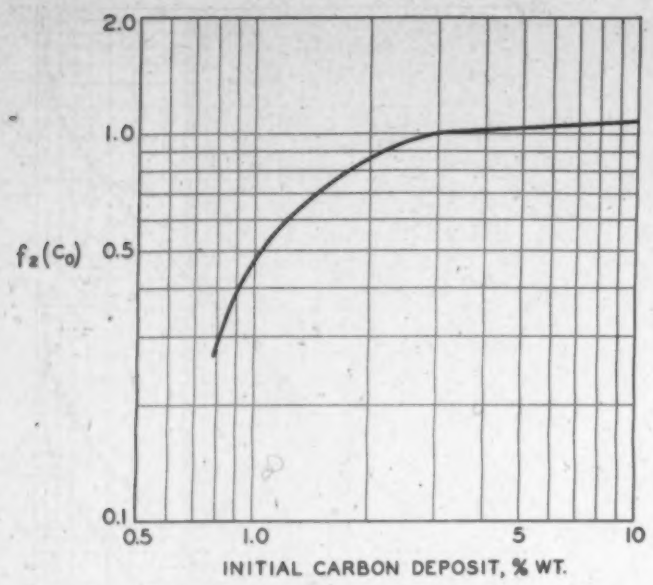


FIGURE 6

Effect of initial carbon deposit on carbon burning rate.

constant for all values of $\frac{C}{C_o}$. The effect of C_o on $\frac{W}{O_m}$ relative to a fixed C_o, taken arbitrarily as 3 weight-percent, was next evaluated by adjusting the experimental values of $\frac{W}{O_m}$ for each coke deposit investigated to 1000° F. and constant $\frac{C}{C_o}$ using tentative forms of Figures 4 and 5, respectively. Charts resembling Figure 6 were obtained. Figure 6 then was used to adjust all experimental values of $\frac{W}{O_m}$ to fixed values of C_o (3.0 weight-percent) and temperature (1000° F.) to obtain a curve similar to Figure 7 evaluating $f_3\left(\frac{C}{C_o}\right)$.

The evaluations of the three functions were made more precise by successive approximations in which deviations associated with any particular variable were eliminated. Figures 4, 6 and 7 are the final charts evaluating the functions in Equation 1, $f_1(T)$, $f_2(C_o)$ and $f_3\left(\frac{C}{C_o}\right)$, respectively. It is interesting to note that the apparent activation energy for carbon deposits, calculated from Figure 4 for the temperature range from 800 to 900° F. where the change in rate of combustion with temperature appears to be influenced only slightly by gas diffusion rates, is of the order of 35,000 calories per gram mol as compared to 44,000 calories per gram mol found by Parker and Hottel[6] for the combustion of brush carbon.

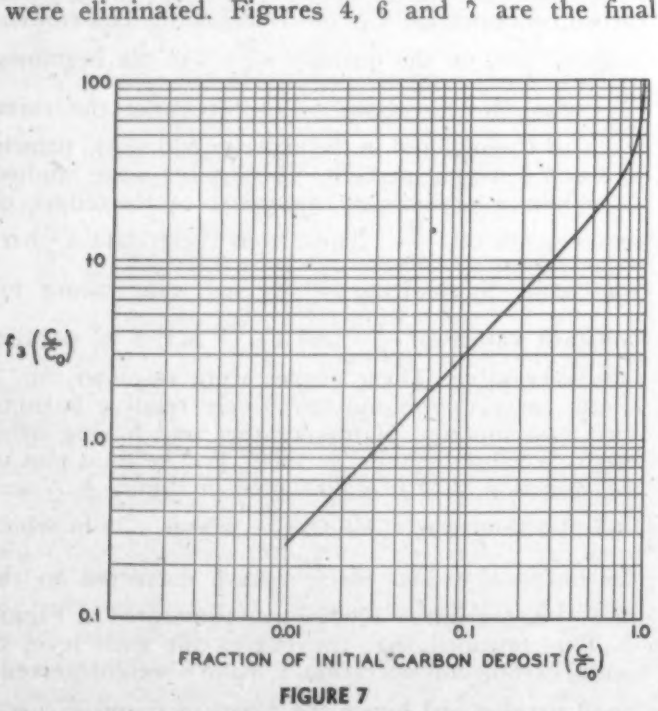


FIGURE 7

Effect of fractional carbon concentration on carbon burning rate.

The accuracy of the correlation was tested by comparing the experimental carbon-burning rates with those calculated from the correlation charts for the same operating conditions. The mean deviations between the calculated and experimental carbon burning rates were as follows:

Weight Percent Initial Carbon Concentration	Mean Deviation, Percent
1	±24
3	±18
6	±18

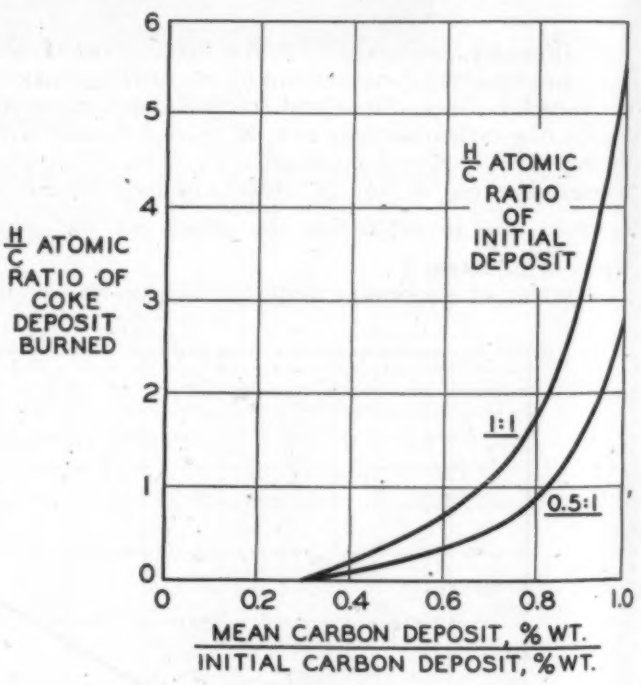


FIGURE 8

Variation in proportions of hydrogen and carbon burned during course of bead catalyst regeneration.

The discrepancies between calculated and experimental data indicated above can be accounted for largely by the probable errors of the experimental measurements of catalyst temperature, carbon concentration and gas composition.

The relative amounts of water, carbon monoxide and carbon dioxide formed during the combustion of coke deposits affect air requirements and heat liberation quantities and must be taken into account in design studies of kilns. The amount of hydrogen in the catalyst deposit entering a kiln is determined principally by the reactor temperature. The amount of hydrogen in coke deposits on bead catalyst covered in these studies ranged from 2.5 to 8 weight-percent. The average was 4.8 weight-percent or an atomic ratio of hydrogen to carbon of 0.6. The atomic ratio

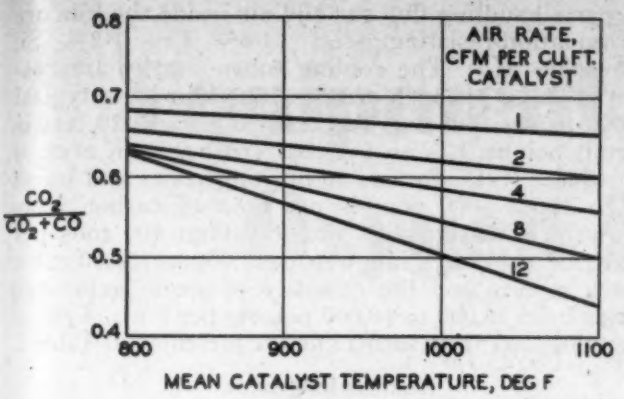


FIGURE 9

Proportions of CO_2 and CO in flue gas regeneration of bead catalyst.

of hydrogen to carbon burned at a given point in a regeneration is determined by the ratio of hydrogen to carbon in the initial coke deposit and the fraction of the initial carbon remaining on the catalyst at the point being considered. The variation in the ratio of hydrogen to carbon burned as the regeneration progresses is illustrated in Figure 8. The relative amounts of carbon dioxide and carbon monoxide leaving the burning zones of a kiln operating with bead catalyst are shown in Figure 9.

The net heat of combustion of coke deposits was determined from heat balances on the experimental data to be:

$$\text{Net heat of Combustion Btu per lb. of carbon} = 4100 + 10100\left(\frac{CO_2}{CO_2+CO}\right) + 3370\left(\frac{H}{C}\right) \quad (2)$$

where, $\frac{CO_2}{CO_2+CO}$ represents the relative volumes of these gases in the flue gas,

$\frac{H}{C}$ is the atomic ratio of hydrogen to carbon in the deposit burned.

Commercial TCC Kilns

The data presented above have been reduced to practice in the design of kilns for commercial TCC units. A schematic drawing of a TCC multizone kiln is provided in Figure 10. Spent catalyst from the reactor is discharged by the elevator into a surge hopper in the top of the kiln and flows through a distributor plate into the kiln proper. The catalyst flows as a solid bed through the kiln where the coke is burned off in a series of burning zones, each of which is equipped with air distribution and flue-gas collection means. Heat liberated by the combustion of the coke is removed from the kiln by banks of cooling tubes located at various levels in the kiln. The regenerated catalyst is withdrawn from the kiln through a baffle-type system into a discharge line leading to an elevator which returns it to the reactor. The rate of flow of catalyst through the kiln is controlled by a valve in the discharge line. The temperature of the catalyst leaving the kiln is regulated to that desired in the reactor by cooling coils located below the bottom burning zone.

Cooling is accomplished by direct generation of steam at 450 psig from water circulated through tubes at a rate five times the design steam-generating capacity of the kiln. The steam flows to the refinery distribution system from a flash drum where a water level is maintained by a feed-water pump.

The combustion of the hydrogen in the coke deposit must be considered in regulating temperatures in the kiln. The ratio of hydrogen to carbon burned is greatest in the first zone of a kiln and decreases rapidly to zero as the regeneration progresses. In commercial practice, deactivation of the catalyst is minimized by holding the temperature of the catalyst below 1000° F. in the first zones of a kiln where a relatively high steam partial pressure exists and then allowing it to increase gradually to 1150° F. in the lower zones where no hydrogen is being burned.

Air, preheated to 600 to 1000° F. by a line burner, is supplied to the kiln at about 2 psig by blowers. It is fed to each zone through inlet ducts which are connected in parallel to large ducts extending along the outside of the kiln. The rate of air feed is controlled by dampers in the inlet ducts. The air is distributed over the horizontal area of the kiln by a grid of inverted V-shaped channels. From the inlet grid the air flows through the moving bed of catalyst to similar flue-gas-collector grids located at the top and bottom of the zone. The internal construction of a zone of the kiln is illustrated in Figure 11. The

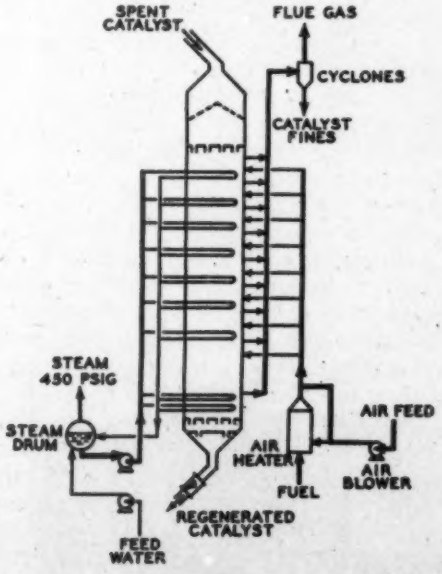


FIGURE 10

TCC multizone kiln.

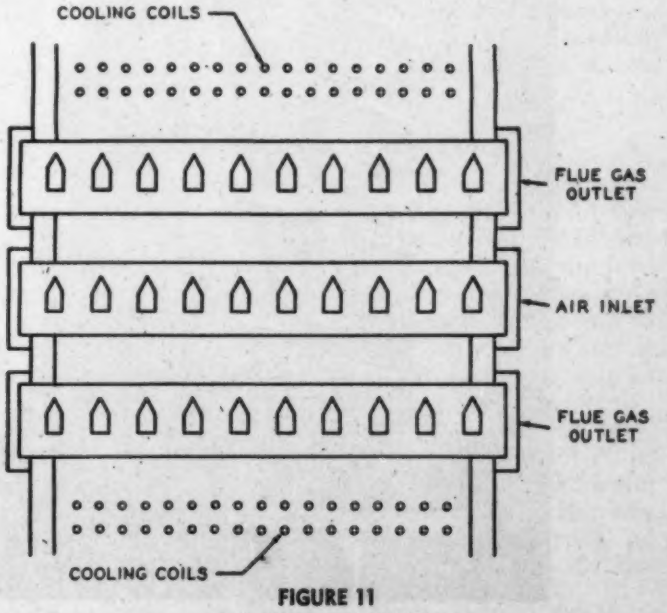


FIGURE 11

Typical zone of TCC kiln.

TABLE 2

Typical Operating Data for TCC Kiln Regenerating Bead Catalyst

ZONE No.	Air Rate, cfm	Oxygen Content of Flue Gas, Percent Vol.	Carbon Burned, Lbs./Hr.	Catalyst Temperature, °F.	
				In	Out
1	2,580	2.7	420	820	955
2	2,140	2.9	552	955	1,060
3	1,830	4.6	463	950	1,050
4	1,730	5.3	408	980	1,080
5	2,470	8.4	412	975	1,060
6	2,190	10.4	333	1,060	1,135
7	2,200	12.3	199	1,065	1,035
8	2,160	13.6	123	1,055	1,110
9	2,180	14.0	111	1,110	1,130
10	1,140	11.3	129	1,130	1,150
Totals	20,620		3,150		

Catalyst rate, tons per hr.	100
Carbon on catalyst, percent weight:	
To Kiln	2.0
From kiln	0.4
Temperature of air to kiln, °F	890
Steam produced, lbs. per hr.	21,400

flue gas flows from the collector grids to large ducts outside the kiln where it is conducted to cyclone separators for removal of catalyst fines before discharging to the atmosphere.

The 30 TCC kilns now operating in the United States are approximately square vessels designed for 3 psig operating pressure. The shells are of carbon steel protected by a 6-inch lining of insulation with a refractory surface adjacent to the flowing catalyst. All parts handling flue gas and air inside the kiln are of oxidation-resisting steel (4-6% Cr., 1-2% Si, 0.45-0.65% Mo). The cooling tubes usually are 2⅜-inch O.D. on 4¼-inch centers. The kiln for a typical 10,000 barrels per day TCC unit is about 120 feet in overall height, has an internal cross-section area of 100 square feet, contains 10 burning zones and burns up to about 5000 pounds per hour of carbon from catalyst circulating at a rate of about 100 tons per hour. Air feed rates range from 17,000 to 25,000 cubic feet a minute and the quantity of steam generated varies from 18,000 to 40,000 pounds per hour. Typical operating data from such a kiln are presented in Table 2.

Acknowledgment

The authors are indebted to R. D. Drew, K. M. Manion, and F. E. Ray of Socony-Vacuum Laboratories for valuable help in obtaining and correlating the experimental data.

LITERATURE CITED

[1] Simpson, T. P., Evans, L. P., Hornberg, C. V., and Payne, J. W., Proc. API **23** (III) 59 (1942); Petroleum Refiner **21**, 401.

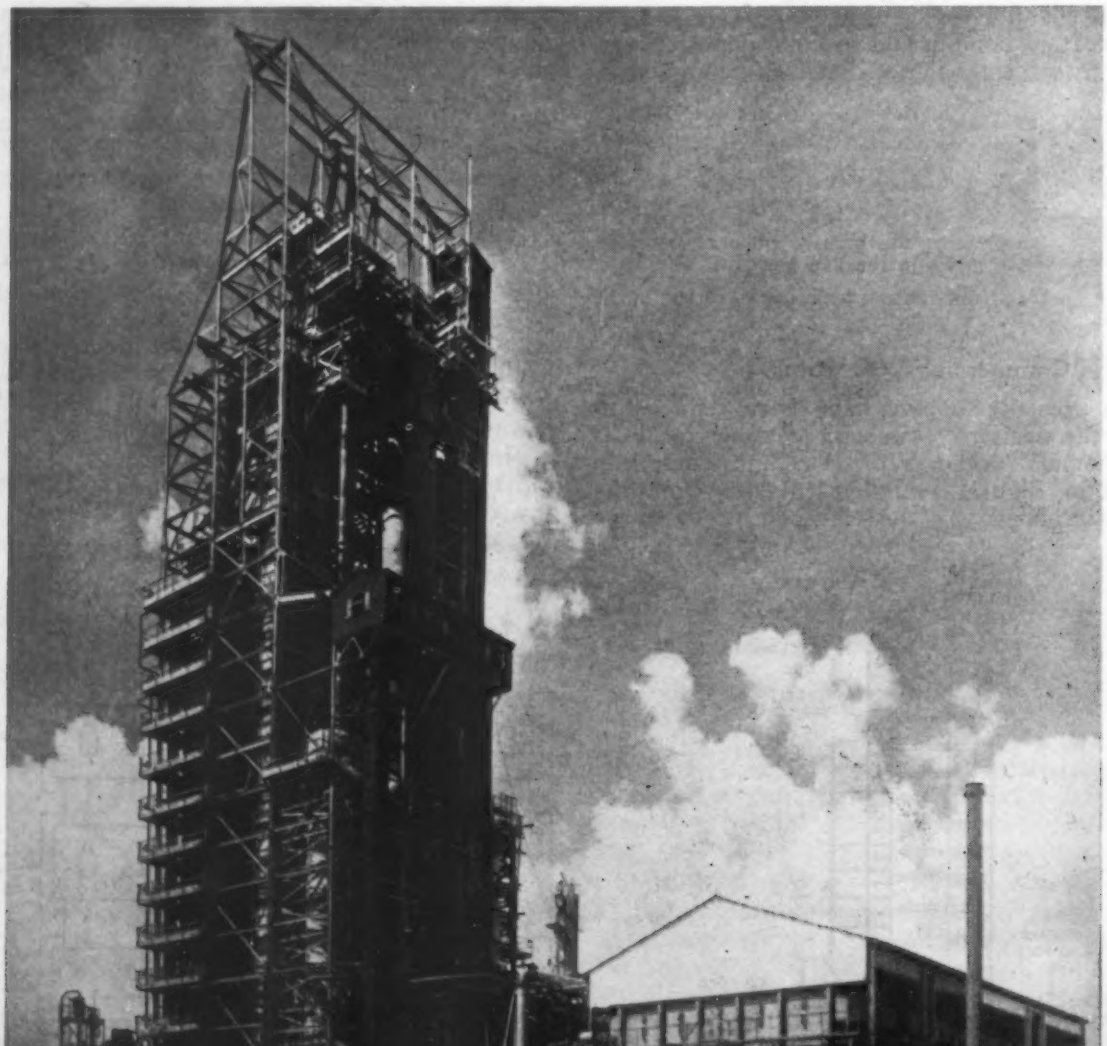
[2] Simpson, T. P., Evans, L. P., Hornberg, C. V. and Payne, J. W., Proc. API **24** (III) 83 (1943); Petroleum Refiner **22**, 353.

[3] Newton, J. W., Dunham, G. S., and Simpson, T. P., Trans Am. Inst. Chem. Engrs. **41** 215 (1945).

[4] Simpson, T. P., Eastwood, S. C., and Shimp, H. G., Proc. API **25** (III) 53 (1945); Petroleum Refiner, **24**, 436.

[5] Porter, R. W., Chem. and Met. Eng. **53**, 94 (1946).

[6] Parker, A. S., and Hottel, H. C., Ind. Eng. Chem. **28**, 1334 (1936).



Thermofor Catalytic Cracking Unit

Equipment for Low Cost Oxygen Production

M. J. CONWAY, Steel Industry Consultant

THERE are two general commercial methods for the production of oxygen: (1) electrolysis of water, and (2) fractionation of air. The first method, electrolysis, is of importance when it is desirable to produce a pure hydrogen stream in addition to the oxygen stream. For the general case where the production of oxygen is the primary objective, the second method, namely liquefaction and fractionation of air, is almost invariably used. There is also a third method of commercial interest—the extraction of oxygen from air by chemical means. Such a process received considerable publicity recently as the result of experiments performed by Dr. Calvin at the University of California whereby oxygen has been successfully extracted from air by the use of a class of chemical compounds called chelates. In general, at present this method has been limited to small scale operations.

The present paper is based on the production of oxygen by the liquefaction and fractionation of air. This method, while comparatively simple in operation, does require very exacting standards relative to the engineering design of equipment and in the application of control instruments during operation. Fortunately, modern equipment designs and control practices have contributed to both the safety and efficiency of the process with the result that the supervision and operation of an air liquefaction unit may be classified in the same category as a single tower crude topping unit.

This paper was prepared for Stacey Dresser Engineering, Cleveland and is presented through its courtesy.

THE composition of the air blanket which covers the earth, consists of three principal classes of constituents: first, the common gases, oxygen and nitrogen, together with traces of the inert gases of the helium family. These are practically always present in constant proportions in the outside air. The second group of components, which are variable in quantity, includes carbon dioxide, water vapor and dust. The third group, which is present only accidentally, includes various gases such as sulphur dioxide in the neighborhood of smokestacks, oil vapors, traces of carbon monoxide from various sources such as exhaust from switch engines and automobiles.

The amount of water vapor present in air differs from day to day and in accordance with the various climatic conditions. Carbon dioxide will vary with the locality but stays fairly constant in that locality. The complete dry air analysis is as follows:

	Percent by volume*
Nitrogen	78.03
Oxygen	20.99
Argon	0.94
Carbon Dioxide	0.03
Hydrogen	0.01

*With traces of other rare gases including helium, neon, krypton, xenon and nitron.

For practical purposes, air may be considered as a binary mixture of nitrogen and oxygen which together make up 99 percent of the whole. The remaining 1 percent is chiefly argon. In the fractionation process, it is necessary to pay special attention to argon only when relatively high purities are specified for the oxygen and nitrogen streams. Argon has a vapor pressure intermediate to oxygen and nitrogen, and to remove argon from these product streams, additional fractionation equipment is required.

Special provision must be made in the liquefaction process for the removal of carbon dioxide, water vapor and dust. Dust may be removed by the use of suitable dust filters. Carbon dioxide and water vapor may be removed by chemical means or by the use of specially designed reversing heat exchanger equipment. Through knowledge obtained from the study of small portable oxygen plants constructed during the war and through experimentation with a pilot plant producing 4000 standard cubic feet per hour of oxygen having a purity of 99.5 percent, it has been successfully demonstrated that oxygen can be produced cheaply by low pressure liquefaction without the necessity for chemical treatment to remove carbon dioxide and water vapor.

The pilot plant referred to in the preceding paragraph was in operation for two years at Olean, New York. This pilot plant has since been removed to the new laboratories of Hydrocarbon Research, Inc., Trenton, New Jersey. This pilot plant operated as part of a research unit to produce ten barrels per day of synthetic gasoline from natural gas.

The unit operations consist essentially of compression, heat exchange, refrigeration and fractionation. The flow through the unit is substantially as shown on the flow-sheet in Figure 1.

Air Compression

The air passes through a filter to remove mechanical impurities and is compressed to 85 psig in two stages. The compressor is designed to handle 10 percent excess air to allow for moisture in the air feed and losses in the exchangers on reversal. The air is compressed to 30 psig in the first stage and cooled to 100° F. in the intercooler and the condensed water is drained off. The air is then compressed to 85 psig in the second stage and discharged into a vertical receiving drum, then into the aftercooler where the temperature is reduced from approximately 300° F. to 100° F.; it then passes to a knockout drum where the major portions of the oil and condensed water are removed. Some of the equipment items, such as filters and knockout drums, are not shown on the flowsheet.

The residual oil and moisture are filtered out in

separators or filters designed for this purpose and the oil vapors are absorbed in passing through a filter containing activated carbon pellets.

The air heater, shown directly above the after-cooler on the flowsheet, is provided for rapid drying out of the system before and after shutdowns when necessary. During normal operation, this heater is by-passed.

Heat Exchange

The compressed air then flows to a multi-annulus reversing exchanger where it is cooled directly against waste nitrogen and oxygen. As the air is cooled, moisture and carbon dioxide precipitate out of the air and tend to foul the air passage. Before this can happen, however, the flows through the exchangers are reversed. The air is diverted to the annulus which had carried waste nitrogen in the previous half cycle. On the other hand, the waste nitrogen now flows through the annulus which contains the ice and carbon dioxide snow. By this reversal, the ice and carbon dioxide snow are re-evaporated into the nitrogen stream and discharged to the atmosphere. This reversing of flows which cleans the exchanger occurs every three minutes. Thus, the exchanger not only cools but also purifies the air, and does so without the necessity of chemicals. The oxygen flows continuously through the innermost annulus without interruption and is, therefore, not contaminated either by air remaining in the reversing annuli, or by water ice or carbon dioxide snow. After the air leaves the exchanger, it is discharged into a surge drum at approximately minus 250° F. where the main portion, or about 70 percent, of the air passes directly from the surge drum to be further cooled by exchange against the waste nitrogen before entering the high pressure column. The remaining 30 percent is used to provide refrigeration.

The enthalpy loss in the products from the unit, that is the difference in heat content between the incoming air and the outgoing nitrogen and oxygen streams, and also any heat leaks into the system must be made up by refrigeration. This refrigeration is obtained by expanding approximately 30 percent of the high pressure air through an engine.

This expansion engine does work by compressing an auxiliary air stream, and the heat content of the expanded air is decreased by an amount equivalent to the work of compression. Thus, the temperature of the air decreases from minus 250° F. to approximately minus 300° F. and thereby supplies the necessary refrigeration to the system. The inlet temperature of the air to the expander is controlled at approximately minus 250° F. because at higher temperatures there is sufficient carbon dioxide remaining in the air to deposit out in the expander and cause it to freeze up. At inlet temperatures below minus 250° F., the exhaust gas will start to condense with a resulting decrease in the efficiency of the expander. The work output of the expander is controlled by throttling the air at the outlet of the compressor before releasing it to the atmosphere.

Fractionation

The cooled high pressure air enters the lower section of the tower below the bottom tray. This section, which is called the high pressure section, contains 20 trays and separates the air into an overhead liquid nitrogen product of low oxygen content and a bottom liquid product containing approximately 35 percent oxygen.

The nitrogen liquid is subcooled by exchange against the waste nitrogen and supplies reflux to the upper section of the fractionating column where it is introduced on the top tray. This section of the

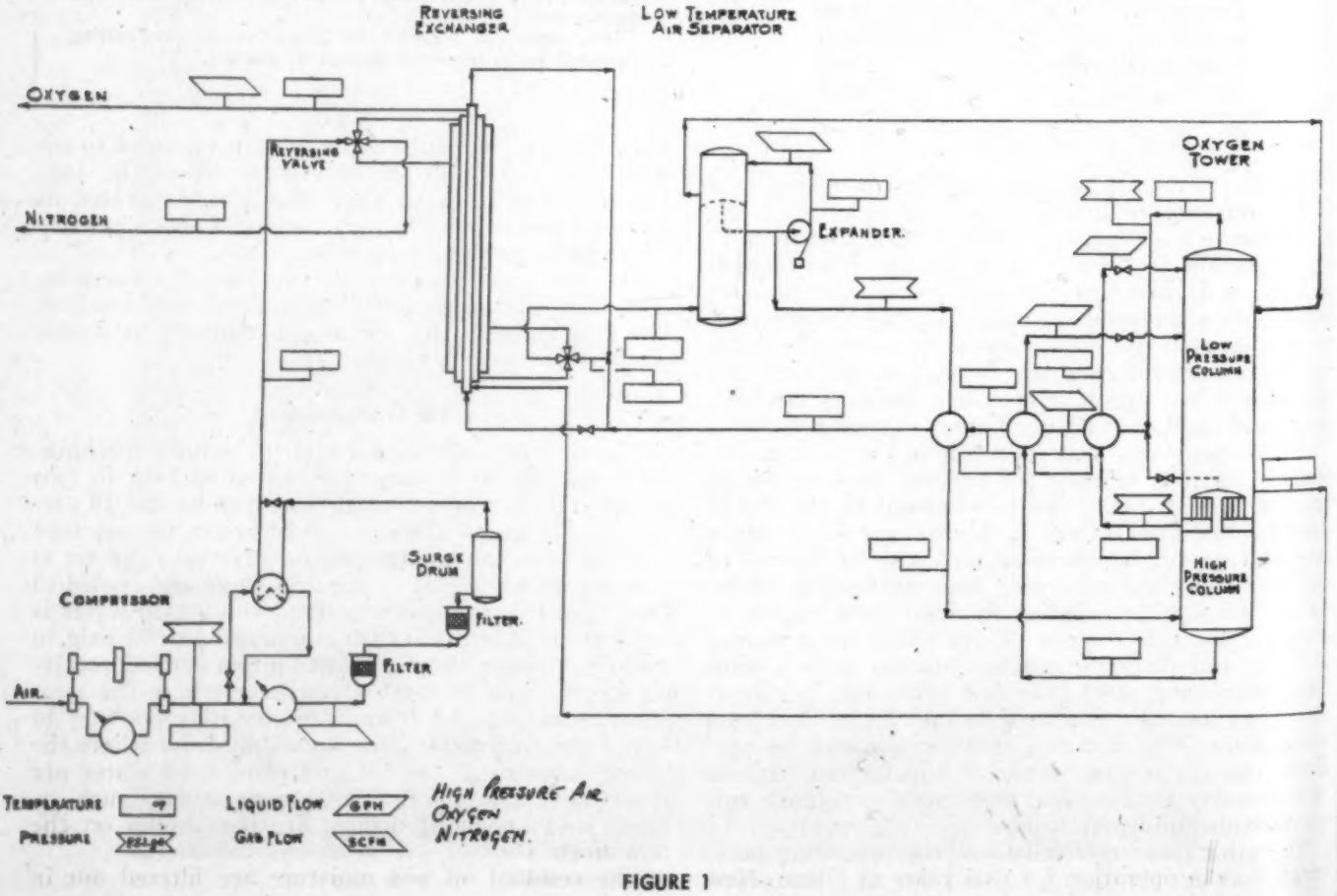


FIGURE 1

column, which contains 40 trays, operates at approximately 10 psig.

The enriched oxygen product from the bottom of the high pressure column is similarly cooled by exchange against the waste nitrogen and then introduced into the low pressure column as intermediate reflux. The expanded air is also introduced into the low pressure column at an intermediate point.

The low pressure tower fractionates the feeds into a waste nitrogen stream which is removed as an overhead vapor and an oxygen product which is withdrawn from below the bottom tray, also as a vapor. The reboiler duty is supplied by the condensation of the overhead vapors in the high pressure section, part of which are withdrawn for reflux to the low pressure section and the balance pass down through the high pressure section as reflux.

In addition to the oxygen and nitrogen, the air feed does contain traces of other gases, such as hydrogen, which are virtually non-condensable and therefore must be vented from the high pressure condenser to prevent vapor-binding. The accumulation of these non-condensable gases would result in a loss of heat transfer and hence a loss of oxygen production and purity. In order to recover the refrigeration in this purge stream, the stream is vented to the waste nitrogen stream leaving the overhead of the low pressure column.

The air feed may also contain traces of acetylene and other hydrocarbons which will accumulate in the reboiler of the low pressure column. These must be eliminated by periodically withdrawing a small quantity of liquid oxygen from the unit. In larger units, continuous blowdown is provided for.

As previously described, the waste nitrogen passes through the three stationary-flow exchangers before entering the reversing exchangers. The temperature of the nitrogen entering the reversing exchanger is controlled by by-passing a small percentage of the nitrogen stream through the center tubes of the bank of reversing exchangers, and recycling this stream back to the cold end of the reversing exchanger where it is mixed with the main nitrogen stream flowing through the exchanger. This recycle stream, which is called an unbalance stream, allows the temperature of the nitrogen stream entering the cold end of the reversing exchanger to be controlled at approximately minus 258° F., thus insuring complete removal of carbon dioxide. Without this temperature control, only part of the carbon dioxide would be re-evaporated thereby eventually causing a shutdown due to excessive pressure drop. The waste nitrogen, after leaving the warm end of the reversing exchanger, is vented to the atmosphere.

The oxygen product passes from the low pressure section of the fractionating tower directly to the inner annulus of the reversing exchanger tubes where its refrigeration is recovered, but its course is not affected by the reversal of the high pressure air and waste nitrogen. The oxygen then enters the service lines and may be subsequently compressed to suit service conditions.

Commercial Units

Experience and knowhow gained from the development work carried on at Olean pilot plant have led to the design of two large sized commercial plants, each to produce 48,000,000 cubic feet of oxygen per operating day. The first unit now under construction at Brownsville, Texas, is to operate in connection with the Hydrocol Process engineered by Hydrocarbon Research, Inc., for the processing of natural gas to produce motor fuel, diesel oil, and crude alcohols.

The second unit is for Stanolind Oil and Gas Company. This unit will also supply oxygen for a Hydrocol plant similar in size and operation to the Brownsville plant.

It is of interest to note that these oxygen units will be the largest thus far built. Compressing air to 75 psig, each unit will produce oxygen at an estimated cost of less than five cents per 1000 cubic feet. This figure includes amortization, maintenance and operating labor. Power (amounting to less than 14 KW per 1000 cubic feet of oxygen) and water costs are excluded from the cost of manufacture as they are both available as by-products of the Hydrocol Process and are automatically covered in the price paid for the natural gas.

In the design of these large oxygen units, it was necessary to draw generously from known petroleum industry equipment practice. A review of the history of design of oxygen plants indicated that at the time when engineering decisions were being made for these large units, the largest plant in operation in the United States had a capacity of approximately 40 tons per day, which is a factor of 1 to 50 when compared to the size of the oxygen plant being considered for the Hydrocol Process. German practice, which was somewhat more advanced in size, indicated single unit operations with a capacity factor of approximately 1 to 10. The following indicates some of the highlights in the approach to the solution of engineering problems involved, and in the selection and design of equipment.

Compressor Requirements

In order to produce 48,000,000 cubic feet of oxygen per day, it is necessary to compress approximately 250,000,000 cubic feet of air per day (174,000 cubic feet per minute) to a pressure of 75-85 pounds per square inch gauge. The cost of reciprocating machines for this service is prohibitive. Considerable progress had been made in this country in recent years on the development of centrifugal machines for handling large volumes of air as is evidenced by the number of air blowers in service on catalytic cracking units and in blast furnace operations. None of these machines, however, had the full capacity, nor did they operate over the full pressure range required.

Engineering layouts were accordingly made by leading designers of centrifugal machines to determine the maximum size of machine feasible. Because of the limitations of the pressure characteristic curves, axial flow machines were ruled out. These engineering studies indicated capacities up to 100,000 cubic feet per minute in a single machine would be satisfactory. Accordingly, the air compression service was divided into two units in parallel, each unit being driven by a 20,000 horsepower steam turbine. Steam for driving these turbines is available as a by-product from the exothermic heat of reaction in the Hydrocol Process.

Similar problems were encountered in the design of the fractionating equipment. The fractionating columns operate at a temperature level of approximately minus 300° F. and accordingly must be fabricated of special materials such as copper, aluminum, and stainless steel. Likewise, the design must be compact to minimize heat leak into the system. Here again,

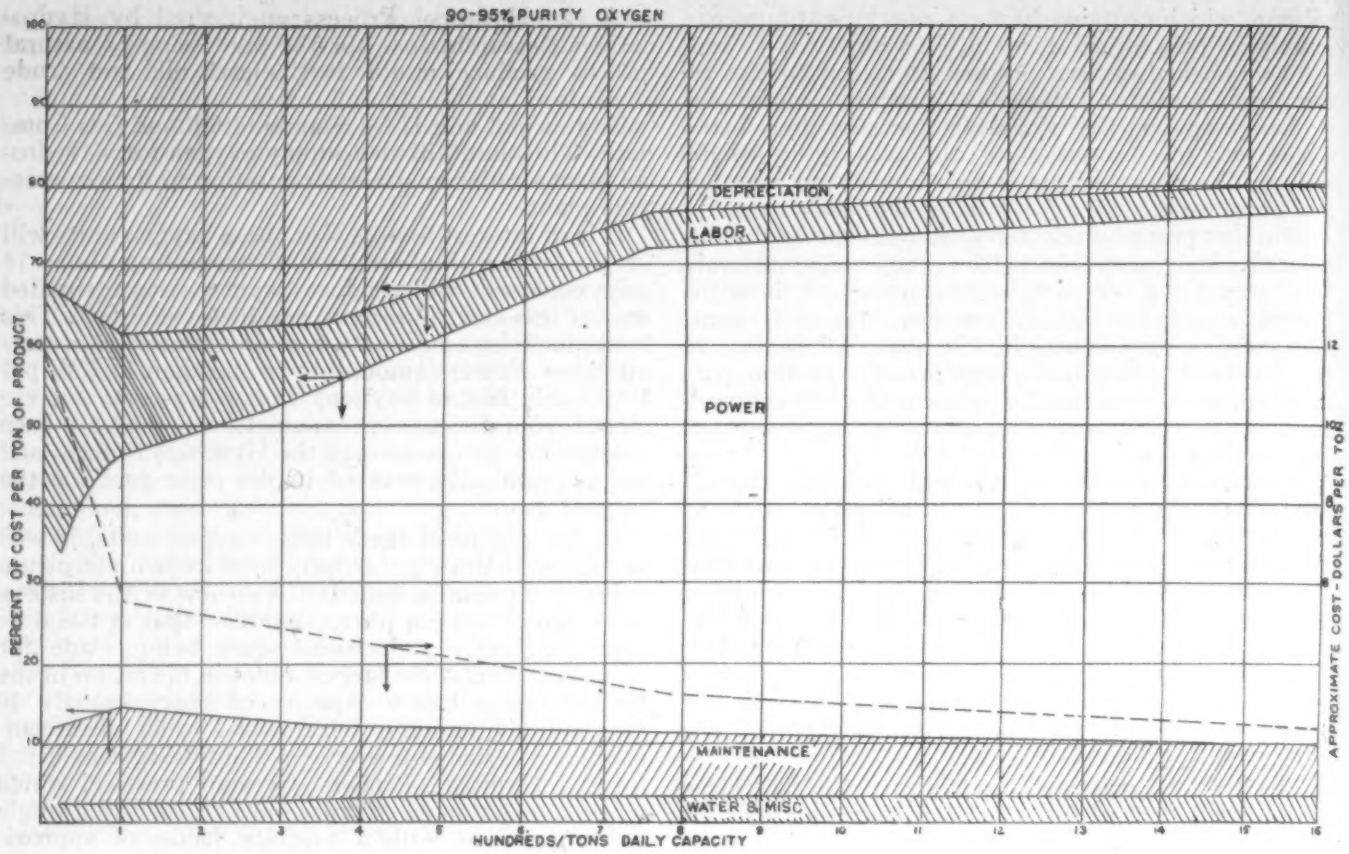


FIGURE 2

it was found advantageous to resort to petroleum refinery equipment practice. Vessels having a diameter of 13 feet could be readily shop fabricated and shipped to the job site. For this size of equipment, again two units operating in parallel were required to handle the specified vapor and liquid loads. Thus, equipment size limitations on the major pieces of equipment resulted in designing the unit as essentially two half-size units operating in parallel.

Other equipment items of importance are the reversing heat exchangers, expansion engines, and reversing valves. In the reversing heat exchangers, the total volume of 174,000 cubic feet of air per minute is cooled from plus 100° F. to minus 275° F. This heat exchange must be accomplished with very small temperature differences of the order of magnitude of 6° to 10° F., and with very small pressure drop on the low pressure nitrogen and oxygen streams. The range of pressure drop is from 2 to 6 pounds psi, depending upon economic factors. For this service, specially designed heat exchangers have been developed with extended surface on both the inside and outside of the main exchanger tube.

Special Equipment

In the pilot plant, the expansion engines are of the reciprocating type. As is the case with the air compressors, the cost of reciprocating expanders for the large unit is prohibitive. Fortunately, in recent years centrifugal air expansion engines have been developed which are completely satisfactory for this service. These machines have thermodynamic efficiencies comparable to the efficiencies of centrifugal compressors.

Since an oxygen unit handles large volumes of air at low pressure, the restrictions on keeping pressure drop to a minimum are more severe than the pressure drop limitations normally encountered in petroleum refining practice. This fact was noted in the design of the reversing exchanger, and it is also of prime importance in the design and layout of piping, valves, fittings, etc. For the large size units, it was necessary to develop specially designed reversing valves. These valves have diameters up to 48 inches, and operate on a 3-minute reversing cycle.

Another equipment problem worthy of mention is insulation. Some of the major items of equipment in an oxygen plant operate at temperature levels below minus 300° F., a temperature level very rarely experienced in the petroleum industry. In small size units, common practice is to enclose all the low temperature equipment in what is known as a cold-box. All the equipment is built in a compact space and then imbedded with insulation with an external sheet metal or ply board structure. Studies for the large size unit indicated that such a procedure would result in an excessive cost and would have the added disadvantage of not permitting ready accessibility to individual equipment items. Accordingly, all major items of equipment for the large units are to be individually insulated.

Cost of Plant

The separation of high purity oxygen from air by fractionation necessitates the use of apparatus designed to operate at temperature levels as low as minus 300° F. For this low temperature service, the fractionating and heat exchange equipment, together with piping, valves and fittings, must be fabricated from metals having a guaranteed Charpy impact value in excess of 15 foot pounds in the fabricated condition when tested at operating temperatures. All metals suitable for this service are costly both in the plate and fabricated forms and will cost in the neigh-

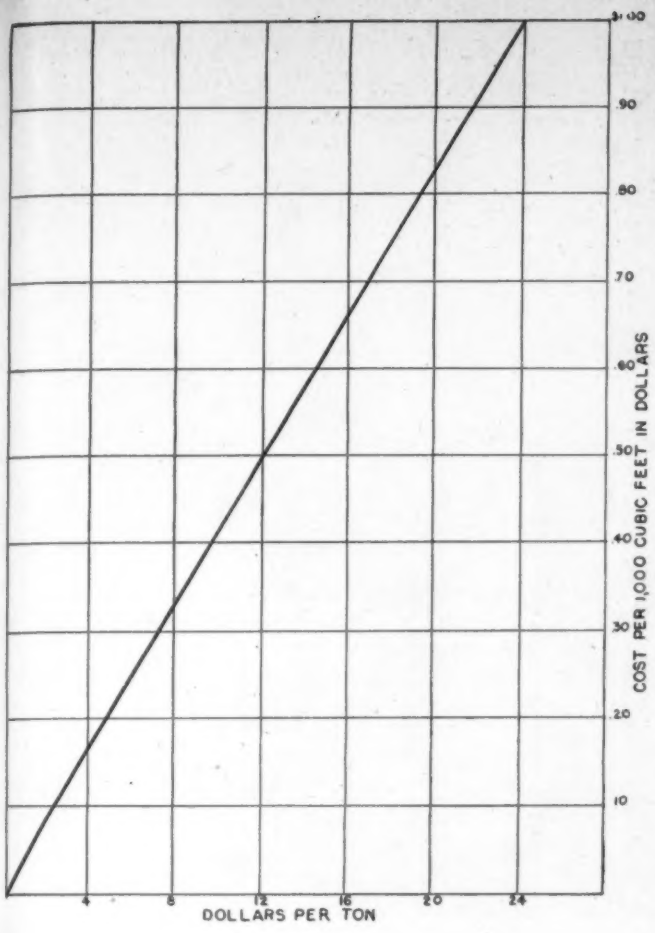


FIGURE 3

borhood of five to one when compared with A.S.M.E. code vessels for normal medium pressure service.

This equipment cost factor plays an important part in the manufacturing cost of oxygen in small plants, but as the plants become larger, then the cost of power is the most important item, especially so where power exceeds 5 mils per kilowatt-hour.

The unsettled price relationships between commodities and wages make it extremely hazardous for any oxygen plant manufacturer to make absolute cost predictions. However, certain items are more or less static and their proportional effect on the cost of manufactured oxygen is shown in Figure 2.

This graph is not intended to interpret correctly the exact cost of oxygen at all points of the scale but it does show trends proportional to the daily output in the several items entering into the production cost as the plants increase in size. The basis on which the graph is drawn is: 15-year depreciation; labor, including all indirect labor costs, at $2.00 per hour; power at 5 mils per kilowatt-hour; and maintenance at 2 percent of the capital investment. The relation between cost per ton and cost per 1000 standard cubic feet is shown in Figure 3.

Future Uses

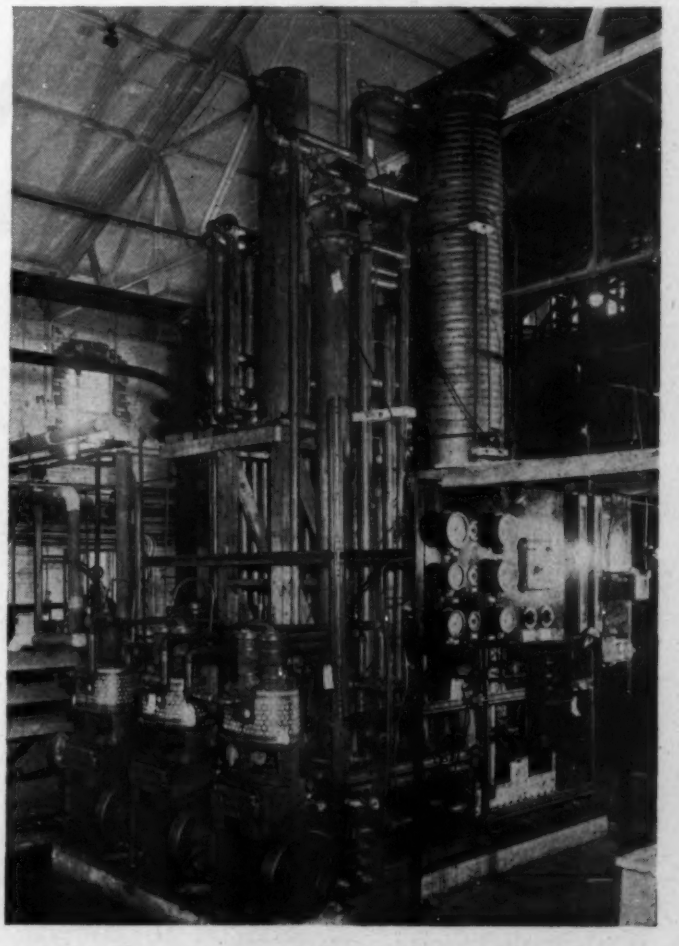
As already stated, the advent of cheap oxygen opens up new uses and applications which cannot be entirely appraised at the moment.

A partial list of operations where the use of oxygen, or oxygen-enriched air, may be used follows:

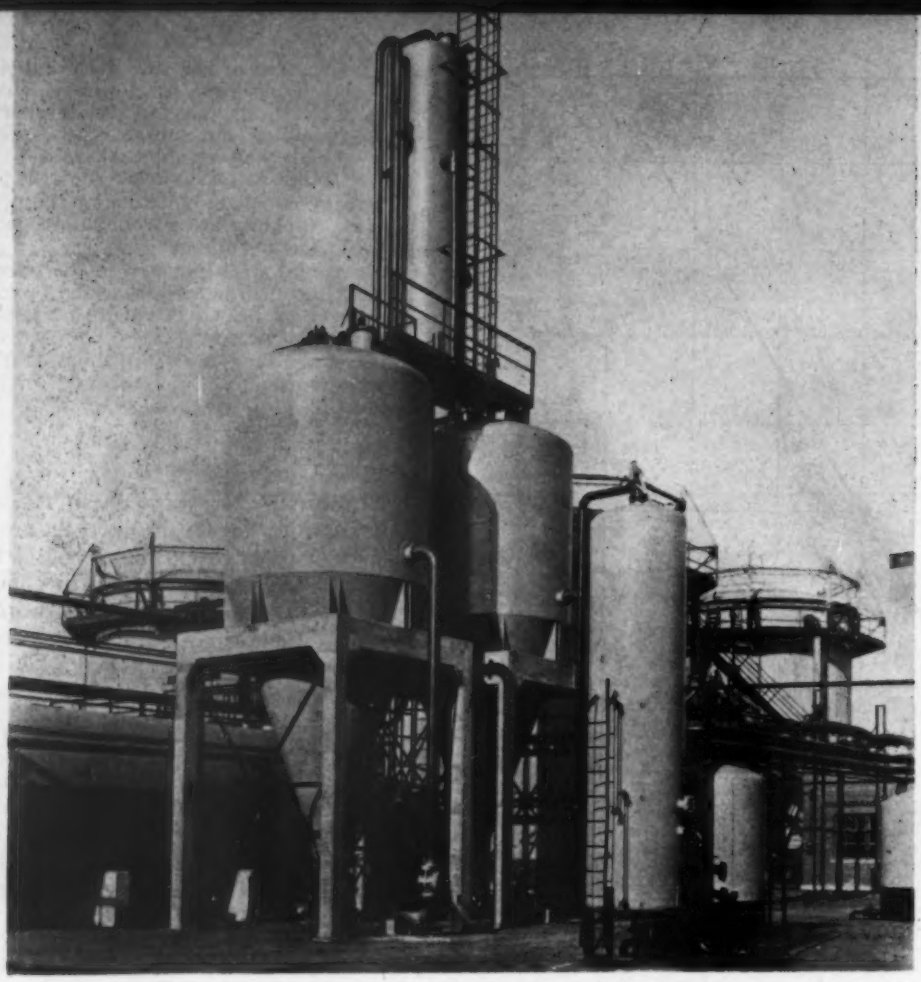
(1) Partial oxidation of hydrocarbon gases for the production of
  (a) Synthesis gas for Fischer-Tropsch operations
  (b) Synthesis gas for ammonia, alcohols, acids
(2) Gasification of coal for the production of
  (a) Synthesis gas for ammonia, alcohols, acids
  (b) Synthesis gas for the Fischer-Tropsch process—yielding automotive fuels, diesel fuels, alcohols, high melting point waxes
  (c) High calorific value city gas
(3) Heavy chemical industry for the production of
  (a) Sulphuric acids from sulphur and sulphides
  (b) Acetate rayons
(4) Iron and steel industry in the operation of
  (a) Blast furnaces—especially ferro manganese
  (b) Open hearth furnaces—accelerated melting down
  (c) Ore treatment
(5) Non-ferrous industry in the operation of
  (a) Burning for the recovery of copper, nickel, zinc, lead
  (b) Refining
(6) Mining
  (a) Liquid oxygen for explosives.

For many years our chemists and metallurgists have said that we could do thus and so—if only—we had access to cheap oxygen. This thought has been put into concrete form in the development of the Hydrocol Process where the production of low cost oxygen in large quantities points the way to a virtual assurance of the continued availability of high grade gaseous fuels and liquid hydrocarbons in our industries without creating upsetting influences in our national economy.

In the development of this low cost oxygen project, research and engineering design have been combined to produce a process which, upon the completion of the two large units now under construction, will have increased the national annual consumption of oxygen by more than 31 billion cubic feet in comparison to the current annual consumption of 19.5 billion cubic feet.



Olean pilot plant of Hydrocarbon Research, Inc.



Cone bottom slurry treating tanks of Cities Service Oil Company, East Chicago, Indiana.

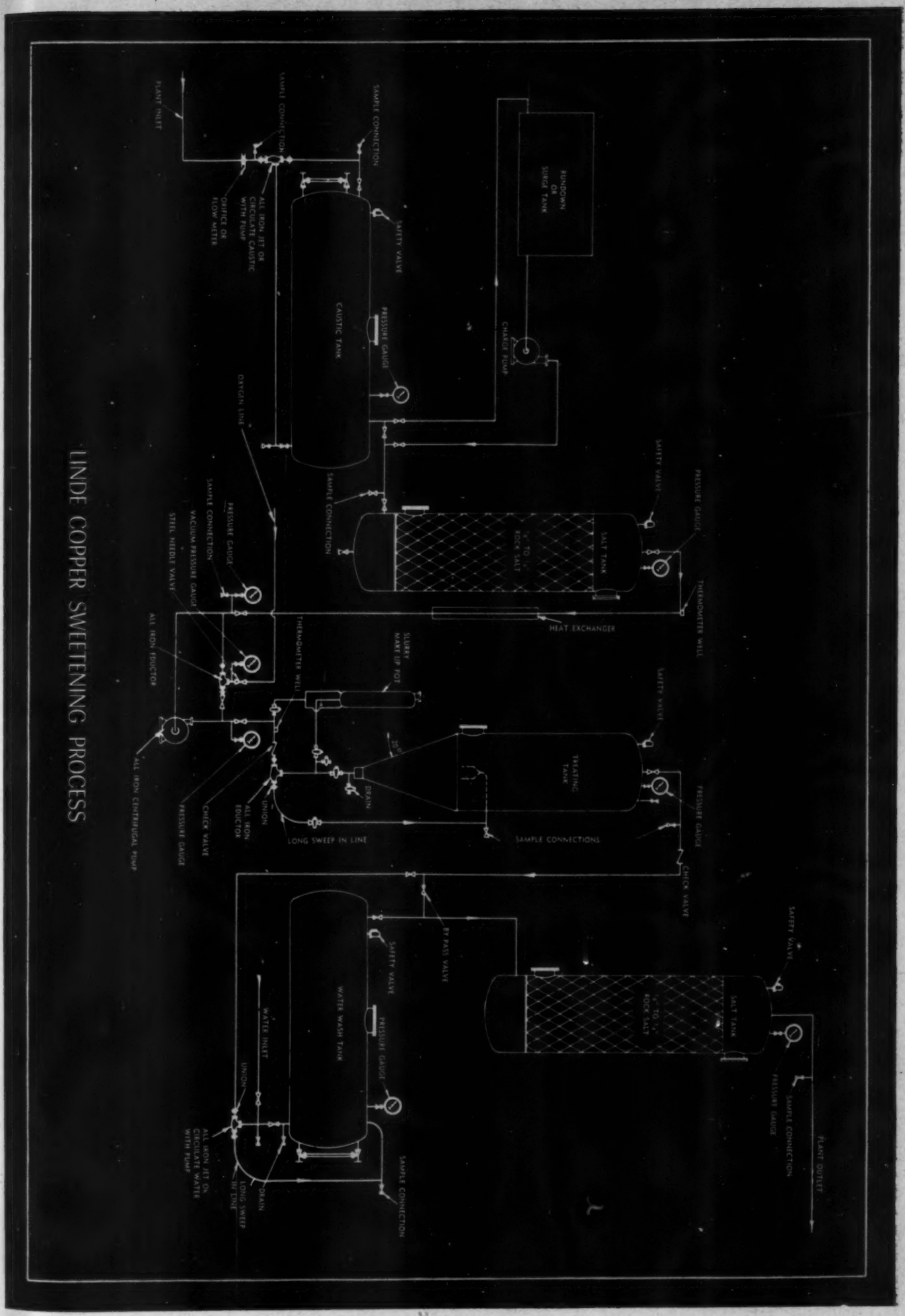
LINDE
Copper Sweetening Process

THE Linde Copper Sweetening Process is used to sweeten gasolines, solvents, kerosines, and distillates. This process converts mercaptans to their corresponding disulfides by chemical reaction between the mercaptans and copper chloride and oxygen. The resultant product is doctor sweet.

The first step is removal of hydrogen sulfide, usually effected by contacting the sour hydrocarbons with a solution of sodium hydroxide in conventional mixing and settling equipment. The sour stock then is passed through a salt filter which removes mechanically suspended water and dissolved caustic soda. The stock then flows through a steam heat exchanger which increases the temperature of the hydrocarbons sufficiently to allow them to dissolve the water to be formed in the sweetening reaction. Since the water of reaction is directly proportional to the mercaptan content and the solubility of water in hydrocarbons increases with increased temperature, a convenient means of continuous removal of this water of reaction from the treating tank is thus available. A temperature increase of 5 to 25° F. usually is sufficient for the average stock; occasionally higher temperature differentials are necessary for the higher mercaptan stocks.

From the heater, the sour hydrocarbons flow to a centrifugal pump which discharges the stock at approximately 100 psig. Approximately 10 percent of the total stock is by-passed around this pump through an eductor for the purpose of introducing oxygen. This by-passed stock is then re-introduced into the suction side of the pump. Pure oxygen for the regeneration of the copper chloride is constantly added to this by-passed portion of the stock at the suction side of the eductor. The by-passed portion containing the oxygen then readily mixes with the main flow, and the oxygen is uniformly dissolved in the sour stock. The amount of oxygen required is approximately 0.10 cubic feet per barrel for each 0.01 percent of mercaptan sulfur. The total flow of hydrocarbons containing the dissolved oxygen is then discharged from the centrifugal pump through a larger eductor, the suction side of which is connected to the bottom of the cone of the treating tank.

The original charge of copper chloride is premixed with 200-mesh inert clay and hydrocarbon stock in a chemicals charge pot. This mixture of clay, copper chloride and hydrocarbons in the charge pot is transferred into the treating tank either by applying pressure to the charge pot, or by educting the slurry


LINDE COPPER SWEETENING PROCESS
PLANT INLET
SAMPLE CONNECTION
SAMPLE CONNECTION
ORIFICE OR FLOW METER
ALL IRON JET OR CIRCULATE CAUSTIC WITH PUMP
SAFETY VALVE
CAUSTIC TANK
PRESSURE GAUGE
RUNDOWN OR SURGE TANK
CHARGE PUMP
OXYGEN LINE
SAMPLE CONNECTION
SAFETY VALVE
PRESSURE GAUGE
SALT TANK
TO 3/4" ROCK SALT
THERMOMETER WELL
HEAT EXCHANGER
PRESSURE GAUGE
SAMPLE CONNECTION
VACUUM PRESSURE GAUGE
STEEL NEEDLE VALVE
ALL IRON EDUCTOR
THERMOMETER WELL
SLURRY MAKE UP POT
SAFETY VALVE
TREATING TANK
DRAIN
ALL IRON CENTRIFUGAL PUMP
PRESSURE GAUGE
CHECK VALVE
ALL IRON EDUCTOR
UNION
LONG SWEEP IN LINE
SAMPLE CONNECTIONS
PRESSURE GAUGE
CHECK VALVE
BY PASS VALVE
SAFETY VALVE
SAFETY VALVE
WATER WASH TANK
SALT TANK
TO 3/4" ROCK SALT
PRESSURE GAUGE
SAMPLE CONNECTION
PRESSURE GAUGE
PLANT OUTLET
WATER INLET
UNION
ALL IRON JET OR CIRCULATE WATER WITH PUMP
DRAIN
LONG SWEEP IN LINE
SAMPLE CONNECTION

from the charge pot directly into the treating tank. Subsequent makeup batches of treating chemicals are added in the same manner with no interruption of continuous operation. The eductor action produces an intimate contact between the sour hydrocarbons, copper chloride and oxygen. This results in immediate sweetening of the hydrocarbons. The clay acts as an inert carrier for the copper chloride and makes possible the continuous circulation of the chemicals as a slurry, thus providing improved contact and immediate reuse of these chemicals.

The mixture of sweetened stock and slurry which contains the regenerated copper chloride flows through a return line into the reactor vessel near the center of the vessel. Here the copper chloride-clay mixture is directed downward and settles into the conical bottom where it is reused. The sweet stock flows upward, discharges from the top of the vessel, and is then contacted with water in a mixer in the ratio of 75 to 95 parts of oil and 5 to 25 parts of water. The water-stock mixture discharges into a settling tank in which the water settles and is recirculated. The hydrocarbon stock, after the settling period, is discharged from the water-wash tank for final treatment. If the stock being processed is a straight-run gasoline, the water wash is usually sufficient.

A vigorous water wash generally is effective in removing all but minute quantities of copper compounds from cracked gasolines or heavy distillates. These hydrocarbons then should be given an additional treatment. The stock may be contacted with an alkaline sodium sulfide solution in essentially the same manner as with the original sodium hydroxide solution. The soluble copper compounds are converted to insoluble copper sulfide and removed from the hydrocarbons. If anti-oxidant inhibitors are required, the sodium sulfide treatment should be followed by another water wash and/or salt filter to remove traces of alkaline sodium sulfide. Small amounts of alkali usually reduce the effectiveness of inhibitors. An alternate method for treating gasolines containing dissolved copper compounds is the addition of a suitable metal deactivator. This deactivator is preferably added to the hydrocarbon stock immediately after the final salt filter. Refiners often find it convenient to add the deactivator with the inhibitor if the end product requires an inhibitor.

The oxygen consumption depends on the quantity of hydrocarbon treated and the mercaptan sulfur content of the hydrocarbon. If the demand does not exceed about 50 cubic feet per hour, oxygen is usually supplied from manifolded cylinders. This should be a dual manifold installation to assure a continuous flow of oxygen. Usually oxygen flows in excess of 50 cubic feet per hour are best supplied by a large-capacity storage unit, consisting of a number of permanently installed special large tubes for storing gaseous oxygen. The oxygen is delivered in liquid form in special tank trucks which include equipment for converting the liquid to gaseous oxygen and discharging it into the storage unit.

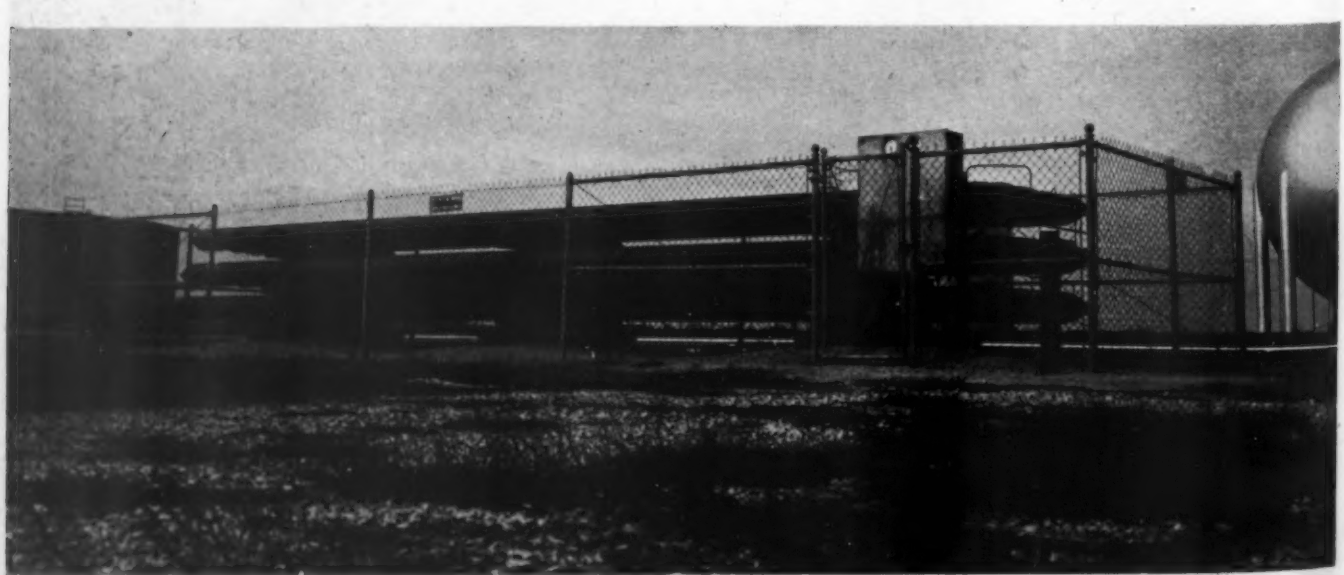
Advantages of the Process

Savings in tetraethyl lead requirements are effected by maintaining a higher base octane gasoline and by improving lead susceptibility of the gasoline. There is no loss of volatile light fractions, and the original base octane number of the gasoline is maintained. Lead susceptibility is increased by elimination of alkyl polysulfides resulting from the doctor process. Addition of sulfur in the treating process is avoided, hence sulfur corrosion is eliminated. Good color stability is obtained and potential gum is decreased.

The simplicity of operation results in low operating costs. Initial investment is low, since vessels or other equipment usually on hand at the refinery often can be used in constructing the unit. An existing treating plant often can be converted at small outlay. The use of dry copper chloride eliminates the possibility of corrosive action and makes it possible to use standard steel or iron equipment.

The eductor used in contacting the hydrocarbons and the treating chemicals makes possible a high operating efficiency which minimizes chemicals consumption. The simplicity of this method of contacting hydrocarbons and chemicals minimizes maintenance. Material losses due to the formation of sludges are eliminated, and the closed system prevents evaporation losses.

The Linde Copper Sweetening Process is licensed by The Linde Air Products Company, New York.



Oxygen storage at Augusta, Kansas, installation.

FOR EVERY GAGE REQUIREMENT

Whatever your liquid level gage requirements, there is a Penberthy Gage that will meet your needs. These gages are suitable for the various pressure and temperature conditions of the oil industry. All Penberthy Gages conform with A.P.I.-A.S.M.E. requirements.

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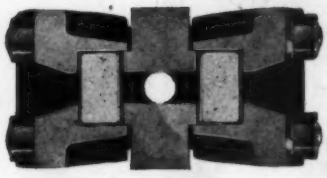
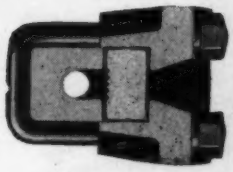


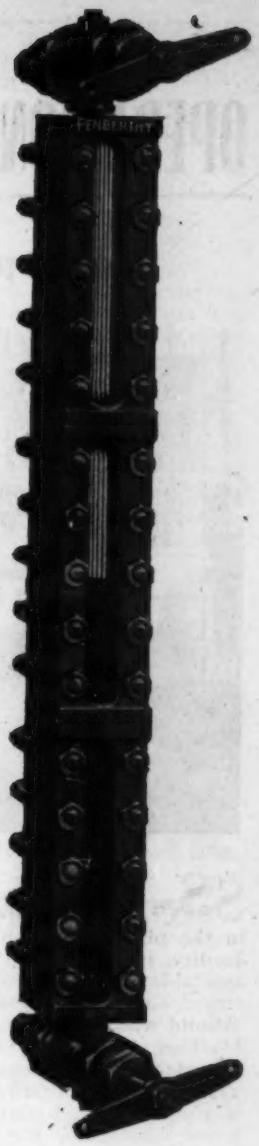
PENBERTHY
Transparent
DROP FORGED STEEL LIQUID LEVEL GAGES

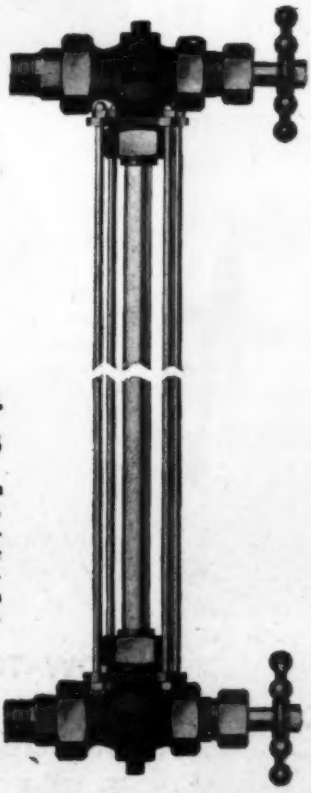
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . . similar to Reflex types.



PENBERTHY *Reflex*
DROP FORGED STEEL LIQUID LEVEL GAGES

Liquid shows black — empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.





PENBERTHY
DROP FORGED STEEL LIQUID LEVEL GAGES

Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.

PENBERTHY *Reflex*
WATER GAGE SET

Water shows black — steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

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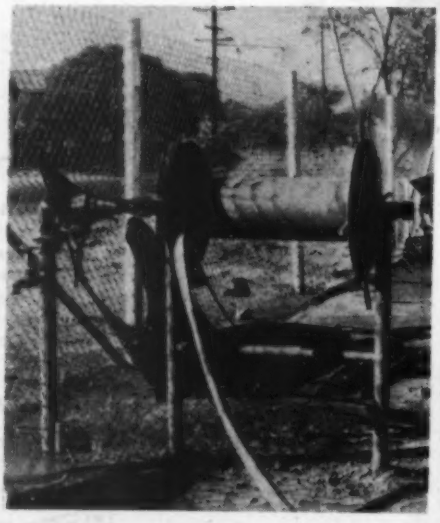
OPERATION HOW TO DO IT MAINTENANCE

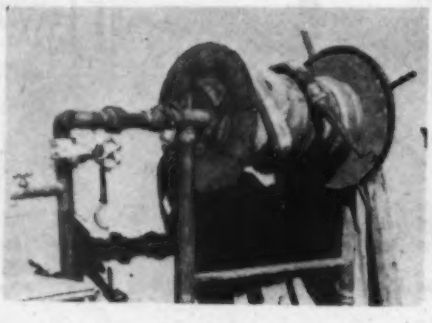
HOW TO— Make Handy Welding Jacks

SPECIAL pipe shapes can be formed in the plant with considerable more facility if adjustable screw jacks are available. All jacks of this type have tripod bases so that leveling on uneven ground will be made easier, this without blocking up one of the legs as is required when four-legged supports are used. The vertical section of the tripods is a piece of pipe containing a hand-set screw for locking the extension slipped into the vertical section which contains the screw jack. "V" blocks attached to the top end of the screw will receive round sections and automatically center in line with any others to be welded.

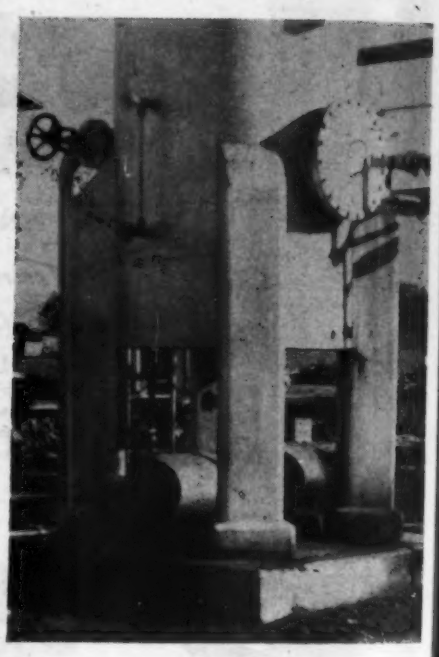
HOW TO— Build Efficient Water Hose Reel

A REEL upon which to wind water hose, used to wash down concrete floors, clean trucks, etc., can be made at little expense as follows: Choose length of lightweight pipe 6 or 8 inches in diameter and weld flanges to each end, solidly enough to withstand water pressure. Weld a nipple to the face of the drum at one end, this for the hose connection. At the opposite end of drum, a one-inch pipe nipple welded to the center of the flange head forms a shaft to rotate upon the post of the reel support. A cast iron cap serves to close the nipple, but this may be removed if a hose is to be attached for use without unrolling the one on the reel. The supply end of the reel is one-inch pipe, fitted to the hydrant with a packed swivel so that water will flow even if the reel is in motion. After use the residual water will drain if reeled in slowly.





HOW TO— Drain Water from A Vacuum Tower

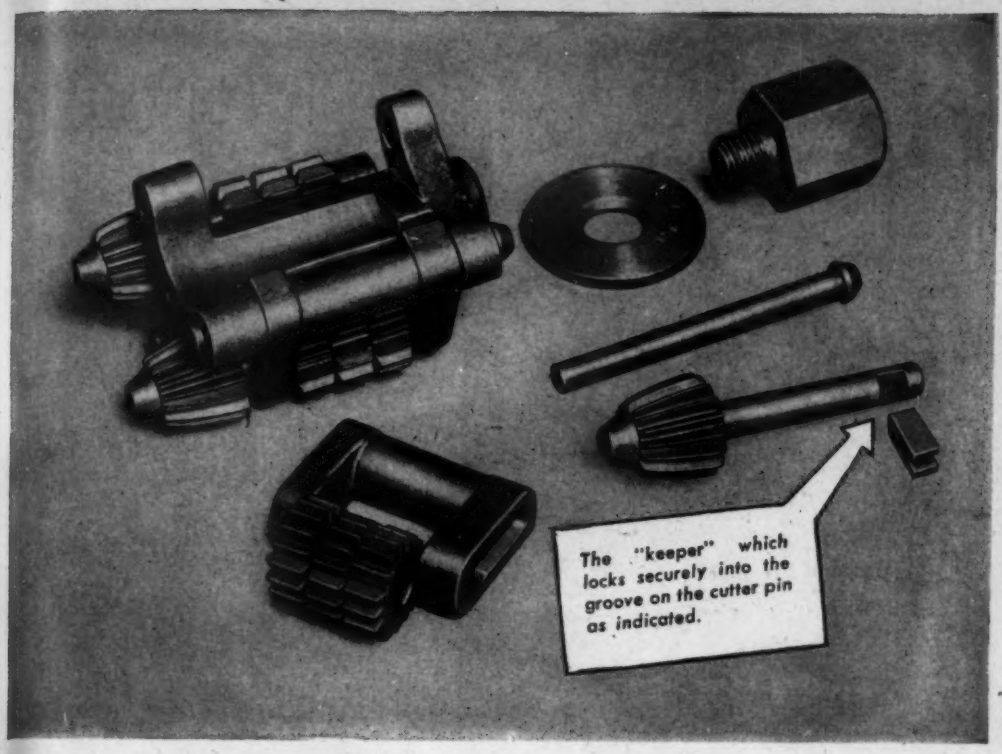


Water drain tank.

WATER accumulated from condensation of steam in a vacuum tower used for manufacture of asphaltic products is drawn off through a small blowcase fabricated from pipe, in the Alma, Michigan, plant of Leonard Refineries, Incorporated. This blowcase is connected to the tower bottom by a line with a valve which is left open until water fills the drum, after which the valve is closed, the water is blown out by air, and the blowcase is again opened to the vacuum tower bottom.

HOW TO— Construct Sand Box To Help Fight Fires

SAND for smothering small floor fires can be stored and kept dry by using self-feeding hopper boxes mounted near the process equipment. The box has a sand



The new Lagonda long surface, swing frame head with one arm disassembled. It's built in seven sizes to accommodate a size range of 2¼ in. to 6 in. Note the keeper which fits into the slot in the arm and locks securely into the groove in the cutter pin. Assembly and disassembly is quick and easy — no tools are needed for the job.

No threaded cutter pins to break

in the new Lagonda 3300 SERIES SWING-FRAME CUTTER HEAD

There's lots of extra life and service in this new long-surface, swing-frame head for refinery cleaning. A new cutter pin locking device has replaced the former threaded cutter pin which was subject to loosening under service vibration, causing occasional breakage.

Now the cutter pin holds tight — secured by a "keeper" which fits snugly into a slot in the arm and locks firmly into a groove in the cutter pin. This new feature adds mileage to your cleaner performance.

Another advantage of this new Lagonda cutter head is extra swing — the largest expansion ever obtained in a swing frame head! It also has built-in "self-feed," which assures ease of handling. Features such as these have caused users to make such comments as, "Best cleaning we have had in years."

This new head is made to give you uniformly better tube cleaning results when driven by Lagonda 1100 series double ball thrust motors, as illustrated at the left.

Write us for the whole story.

Elliott COMPANY

Lagonda Division, SPRINGFIELD, OHIO

Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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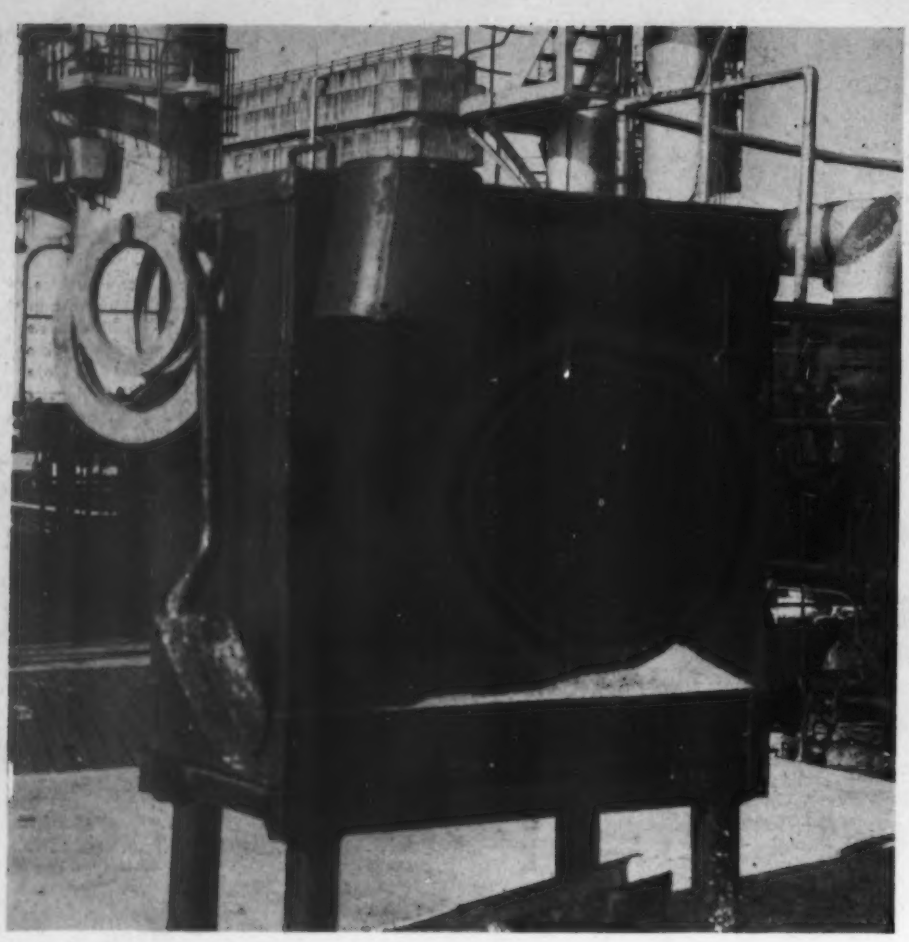
DISTRICT OFFICES IN PRINCIPAL CITIES



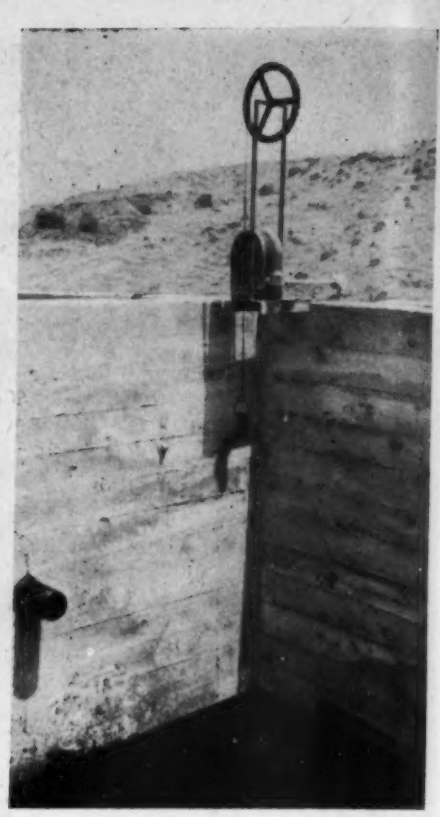
A handy self-feeding sand box with a water-tight top and a self-feeding hopper is shown above. Small floor fires call for such a facility in many plants. Shovel and bucket hang on convenient hooks.

hopper top section which is fitted with a water-tight cover and has a bottom which institutes a self-feeding hopper such as used by poultry raisers. So long as the hopper is filled with sand, a supply is always available in the open section below. Hooks on the open side hold a bucket and a shovel for use when needed.

HOW TO—

Construct an Automatic Pumper

TO CONTROL a motor driven pump removing water, or other fluid from a tank or separator a positive control of high and low levels can be obtained. The start-stop switch of the motor is installed on the wall of the pit, attached to a substantial bracket. Two vertical posts support a sheave over which a flexible cable is run. One end of this cable is fastened to the float on the surface of the liquid while the opposite end is weighted to keep the line taut. Knots in the cable are placed at predetermined points so that, when moving up, the high point engages the switch lever and starts the motor. After the level is reduced to the low point, another knot opens the switch to stop the motor.



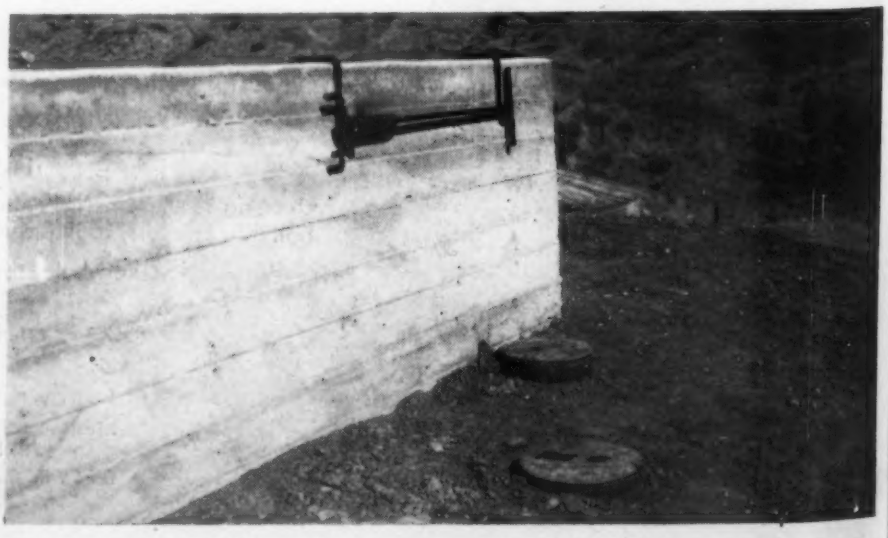
Above is shown an "automatic pumper" consisting of float attached to flexible cable equipped with knots which engage electric pump starting switch.

HOW TO—

Install Gate Valve Stem Extension

WHERE valves on buried lines are set so that it is inconvenient to open or close the gates by hand, operating convenience can be attained by perforating valve wheel covers so that a forked extension stem can be used. The covers are drilled to match the spokes of the hand wheels, and the extension stem has a fork which can be inserted in the holes to engage the spokes for opening or closing the valves. Hooks on a nearby wall keep the handle in a convenient place for use.

Below is shown a handy gate valve installed to facilitate operation of valves which are set so as to be inconvenient to open or close by hand.



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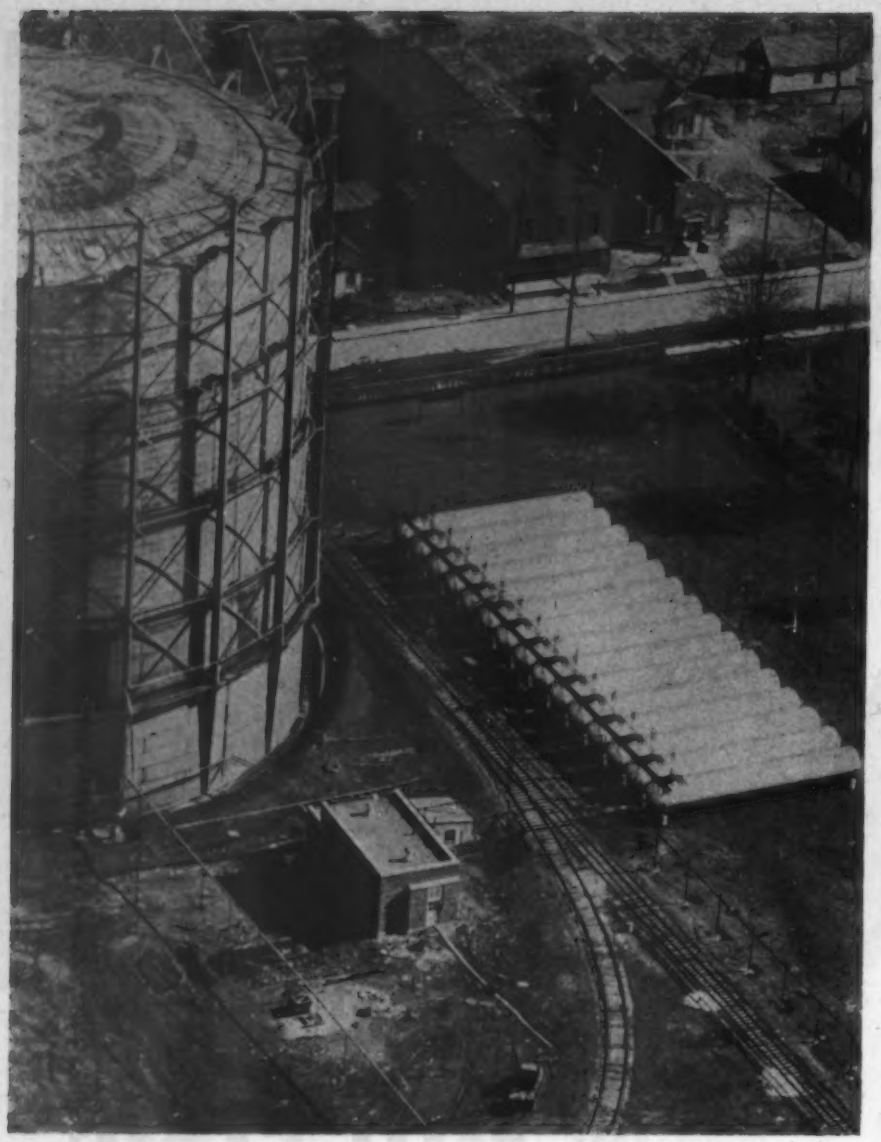


A typical utility installation, equipped for unloading LPG from tank cars into pressure storage adjacent to a gas holder.

GEORGE R. BENZ, Manager
Chemical Products Department
Phillips Petroleum Company

(Before the natural gas department of the American Gas Association in Chicago, May 1, 1947.)

Liquefied Petroleum Gas Supply and Demand Outlook

FOR PURPOSES of this discussion and so that we may all be thinking alike as regards product specifications, the following are definitions of the principal accepted grades of liquefied petroleum gas:

1. **Commercial Propane:** A product containing 95 percent minimum of propane and/or propylene and dehydrated to pass the standard test for dryness. The vapor pressure at 100° F. should not exceed 200 psig. The chemical formula of propane is C_3H_8 and for propylene C_3H_6 and they are usually referred to as C_3 hydrocarbons.
2. **Commercial Butane:** A product composed essentially of butanes (isobutane, normal butane, and butylenes), with lesser amounts of propane and/or propylene, and with a vapor pressure not in excess of 80 psig at 100° F. The chemical formula for iso and normal butane is C_4H_{10} and for butylenes C_4H_8 They are C_4 hydrocarbons.
3. **Propane-Butane Mixtures:** A mixture of the above. The usual products are those having vapor pressure at 100° F. of 80 psig (summer grade) and 100 psig (winter grade).

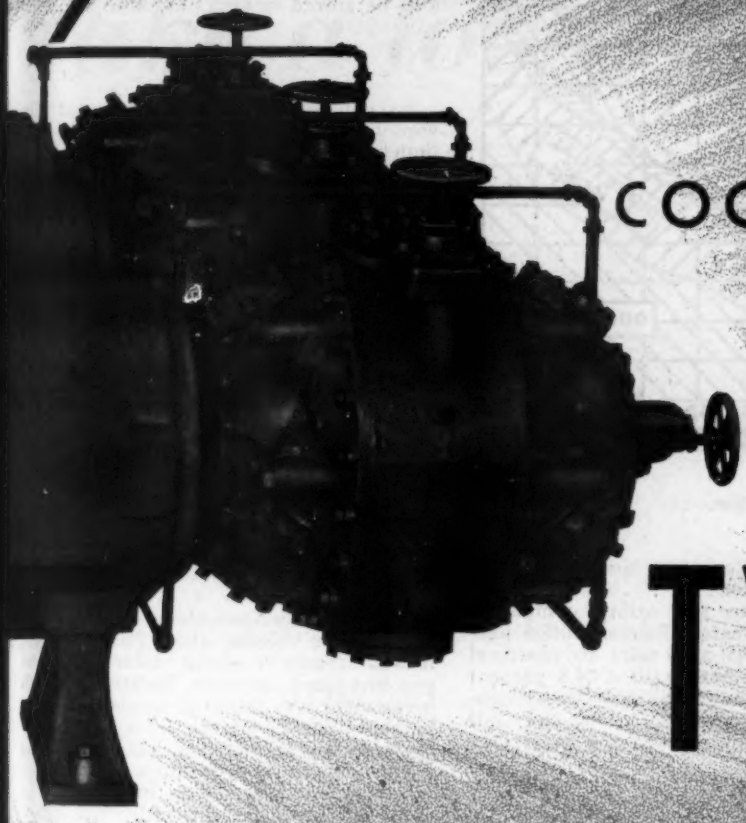
Demand

During the past 20 years the liquefied petroleum gas industry has grown tremendously. Sales of liquefied petroleum gas increased from only 465,000 gallons in 1926 to an estimated 1,425,000,000 gallons in 1946. Figure 1 shows the increase in demand by years. Of particular interest is that the 1946 estimated sales were 33.5 percent greater than the sales in 1945 and more than 3 times the sales in 1941, the last full year of production and sales prior to the war.

The increase in demand by gas utility companies which has been from 1,500,000 gallons in 1928 to an estimated 80,000,000 gallons in 1946, or 5300 percent, as shown in Figure 2.

The increasing demand by gas utilities has resulted from use by small town gas

great new compressor



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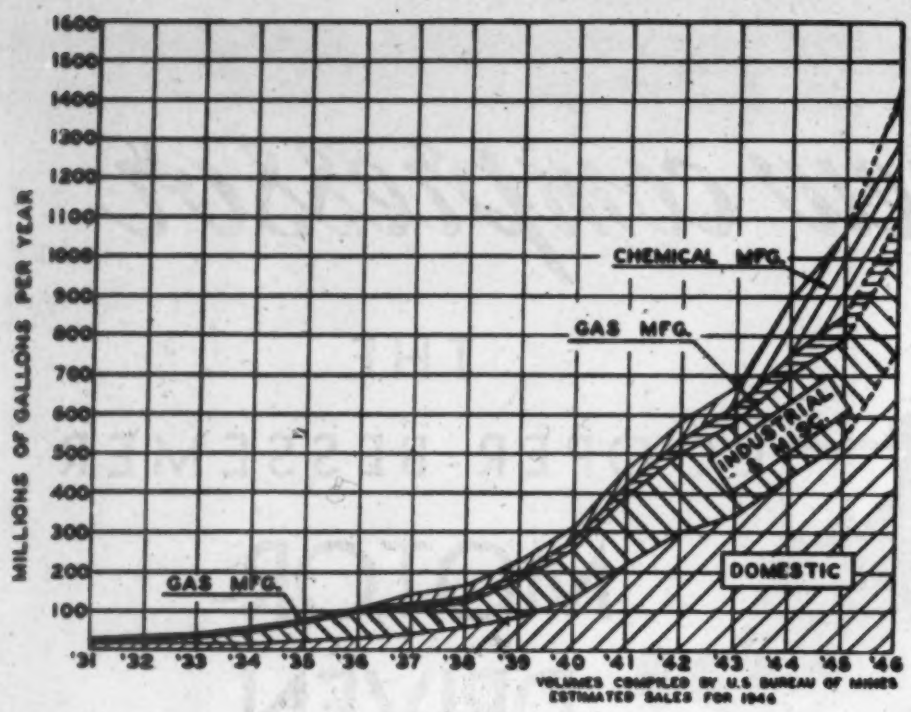

FIGURE 1

Liquefied petroleum gas marketed production.

plants distributing undiluted propene, or air diluted butane or propane, for peak shaving, for standby to natural gas, for underfiring coke ovens, for cold enrichment of low Btu gas, for reforming and for re-enrichment at or near ends of long manufactured gas transmission lines. The major portion of the large increase since 1940 has been for enrichment, peak shaving, underfiring ovens and standby purposes.

Sales for household purposes were estimated to be 763,000,000 gallons in 1946, an increase of 43.1 percent over 1945 and for industrial purposes 257,000,000 gallons, an increase of only .02 percent over 1945. Sales for chemical purposes in 1946 were estimated to be 325,000,000 gallons, an increase of 44.8 percent over 1945.

1946 sales to gas utility companies showed the greatest increase (48.6 percent) over 1945 and sales to chemical concerns were next with a 44.8 percent increase with an exceedingly heavy concentration of such sales along the Gulf Coast with deliveries for the most part by pipe line.

Future sales of liquefied petroleum gas are expected to continue to increase at a healthy rate and for the next few years to be held quite closely to the ability of the petroleum industry to obtain long distance transportation (pressure tank cars, barges, pipe lines and tankers) as well as equipment and other facilities for recovery, treating and storing the product at manufacturing plants.

There is a very definite trend towards the use of more and more propane as compared with mixtures or butane. This trend is expected to continue. Hence the consumer that installs storage suitable for propane is the one which will secure maximum long time utility from his investment since butane and mixtures can also be stored in tanks suitable for propane.

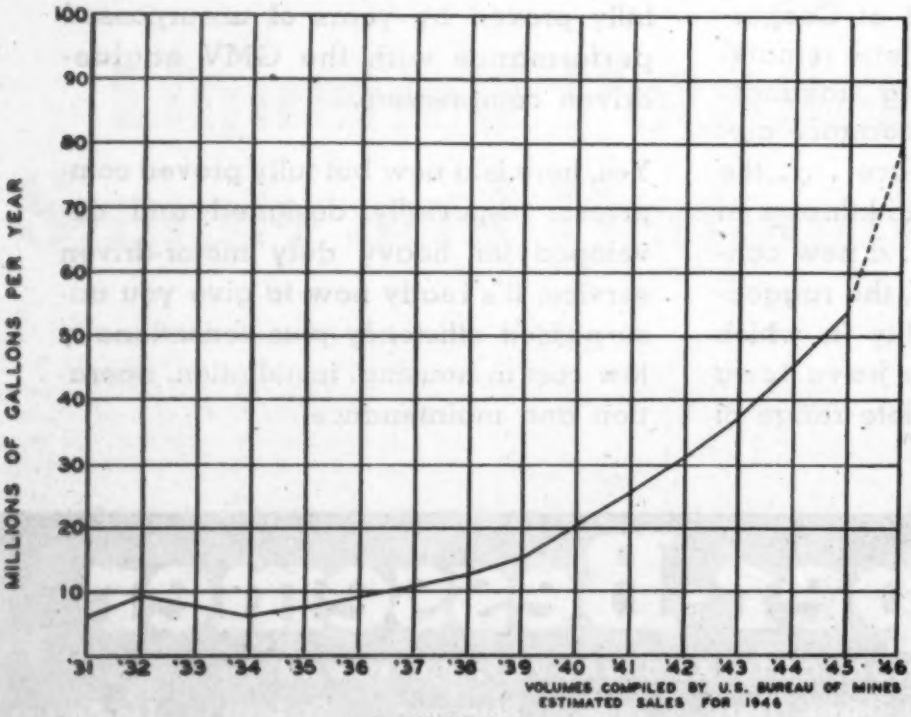

FIGURE 2

Supply

Except for the past winter and the winters of the war years, the supply of liquefied petroleum gas to date has been adequate with an oversupply during much of the time, especially during the spring and summer months. The past few winters' shortages have for the most part been due to a lack of pressure tank cars caused by their high priority war uses or in the case of last winter, by delays in deliveries of new cars.

However, in certain local areas where the market requirements have been supplied entirely by tank truck direct from a local gasoline plant or refinery, the demand has now reached a point where available production is oversold and outside supplies must be imported by large transport or by tank car if further increases in sales are to be made. This naturally poses some price problems for the distributor who is faced with such a predicament.

When liquefied petroleum gas was first marketed in volume, about 20 years ago, it was largely a waste material to the gasoline plant operator. Relatively small investment was required to make a marketable liquefied petroleum gas product. Now, however, liquefied petroleum gas is no longer a byproduct but a coproduct requiring large investment in plant facilities to make additional quantities available.

It has been estimated that there are some 14,400,000,000 gallons per year of C_3 and C_4 hydrocarbons potentially available at gasoline plants, cycling plants and at refineries of which 9,360,000,000 gallons are at refineries. This total is approximately 10 times the amount marketed in 1946. To "dig deeper" into this huge potential supply of C_3 and C_4 hydrocarbons and make them available, the producer must invest more capital in manufacturing facilities for as the rate of recovery or extraction increases, the investment and operating cost likewise increases. Furthermore, nearly all of the potential supply available is now being used for some purpose and little sent to the flare, such uses being for plant or refinery fuel, for maintenance of Btu of natural gas, especially where such natural gas has a high nitrogen content, for use for repressuring purposes at cycling plants, for the manufacture of motor fuel and for the manufacture of carbon black.

Hence, if this potentially available supply of C_3 and C_4 hydrocarbons is to be utilized by the liquefied petroleum gas industry a sufficient price incentive must be created to divert it from present uses, including a satisfactory payout on the producer's investment needed to make the hydrocarbons into specification products and to transport them to the consumer or distributor. Due to the increase in material and labor costs and in the alternate values of C_3 and C_4 hydrocarbons, the incentive needed is now greater than at any time in recent years.

An example of the approximate in-

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vestment cost for a refiner planning to recover 8 car loads of propane per day, is as follows:

Recovery, treating and loading equipment	$ 700,000
Storage (5 days' production)	180,000
Pressure tank cars	1,110,000
	$1,990,000

The petroleum industry confidently expects to find new oil and gas fields, however, as the search continues and deeper and deeper horizons are explored, the cost of new oil and gas supplies necessarily increases and consequently the presently marketed volume plus the newly found and marketed supplies must carry the cost of this exploratory effort. The first increment of propane obtained from new plants built in new fields will, of course, be lower cost than production at many presently operating plants having a high rate of extraction.

Twenty years ago there were less than 10 plants producing liquefied petroleum gas whereas today there are about 480 plants located in 22 states. Moreover, there are approximately 40 liquefied petroleum gas recovery plants under construction or definitely projected for construction within the next 18 months. These plants plus expansion at existing plants are expected to add 845,000 gallons per day by the end of 1947 and another 1,250,000 gallons per day during 1948.

Consumption Expands

The consumer use of liquefied petroleum gas has continued to expand because of the relatively quicker delivery of lighter consumer equipment needed to store, handle and utilize liquefied petroleum gas as compared with the much slower and more difficult procurement of heavier and more special equipment needed to recover, treat and transport liquefied petroleum gas. Although the liquefied petroleum gas demand at present appears to be satisfied, it is expected that the demand will continue to increase and exceed the supply and transportation in the next 6 to 12 months, especially during the coming fall and winter.

The liquefied petroleum gas producers are doing everything possible to hasten completion of manufacturing projects now under way and to expedite delivery on transportation equipment on order.

A factor of significance to the future supply is the increased interest in modifications of the Fischer-Tropsch process for converting dry natural gas into motor and diesel fuels, liquefied petroleum gas and alcohols. One process can produce about 66 gallons of liquefied petroleum gas per 1000 gallons of motor fuel. Two plants are planned for early construction for conversion of natural gas into motor fuels and other products having a reported combined motor fuel capacity of approximately 12,000 barrels per day.

Large quantities of natural gas marketed today contain appreciable amounts of inerts, nitrogen and carbon dioxide. Certain fields produce natural gas containing as much as 10 percent nitrogen and other inerts.

Since most natural gas sold requires the maintenance of a certain minimum Btu, 970 for example, it is obvious that when inerts are present that large amounts of ethane, propane and in some cases butane, must remain in the gas sold to distributing concerns. It seems quite likely that in the future blends of ethane and propane or ethane and butane may be used for certain special liquefied petroleum gas applications. For example, ethane-propane mixtures and ethane-butane mixtures can be shipped in ICC-105A400 and 105A300 tank cars, see Figure 3. These types of cars are currently employed for the transportation of propane.

Transportation

The transportation of liquefied petroleum gas in bulk is by tank car, transport truck, pipe line, barge or tanker or by combinations thereof. Pipe lines move huge quantities of C_3 and C_4 hydrocarbons for chemical use annd for further processing into motor fuels. A little over half of the liquefied petroleum gas marketed for industrial heating, gas manufacturing by utility companies and for household purposes is transported by tank car.

There are approximatly 4000 pressure tank cars in liquefied petroleum gas service excluding about 350 in the synthetic rubber program, of which 3000 are of ICC-105A specification or suitable for propane. There are on order approximately 3300-105A cars and the average rate of production is about 200 cars per month or 30 percent of the car builders' capacity to produce. Shortages of material and critical demands for underframes for other seriously needed types of railway cars (box cars, for example) are delaying completion of badly needed liquefied petroleum gas tank cars.

One company has announced the acquisition of a 6700 ton dry cargo ship and conversion to handle liquefied petroleum gas. It is reported that this ship is scheduled to be ready for its first liquefied petroleum gas movement this coming fall. Several companies are actively studying possible large scale barge transportation of liquefied petroleum gas.

Due to the critical shortage of pressure tank cars both during the war years and the past two winters, a great impetus has been given to long distance transport trucking of liquefied petroleum gas from refineries, gasoline plants and pipe line terminals. It is expected that when pressure tank cars are again in adequate supply that certain of this trucking will be diverted to rail movement in order to reduce costs.

The outlook for adequate transportation during the next 12 months is not too encouraging, however, thereafter transportation should not be a problem since deliveries on new transportation can be planned and timed to coincide with completion of new liquefied petroleum gas producing facilities.

TABLE 1

Type of Tank Car	Max. Vapor Pressure Psig. at 105° F.	Ethane-Normal Butane Mixture	Ethane-Propane Mixture
105A300	225	Ethane 20% n-Butane 75%	Ethane 6% Propane 94%
105A400	300	Ethane 34% n-Butane 66%	Ethane 20% Propane 80%

Prices

In 1926 the propane tank car price was in the neighborhood of 11 cents per gallon, f.o.b. Group 3. During the 15-year period ending in 1941 the tank car price gradually declined as sales increased to a low of about 20-25 percent of this price, at which level prices were frozen by the OPA in the fall of 1941.

In the past there have been no published prices on liquefied petroleum gas hence the data in Figure 4 for liquefied petroleum gas are based on general information. Data on motor fuel and crude oil are from Platt's Oilgram.

It is expected that butane will in general command a higher price than propane, especially during the fall and winter when large quantities of C_4 hydrocarbons are blended directly into motor fuel to obtain volatility and consequently such butane is worth the price of motor fuel to the refiner. Moreover, butane has an octane number of almost 100. The Natural Gasoline Association of America has been conducting some road tests recently which indicate that it may be possible to increase the vapor pressure of regular motor fuel (winter grade)

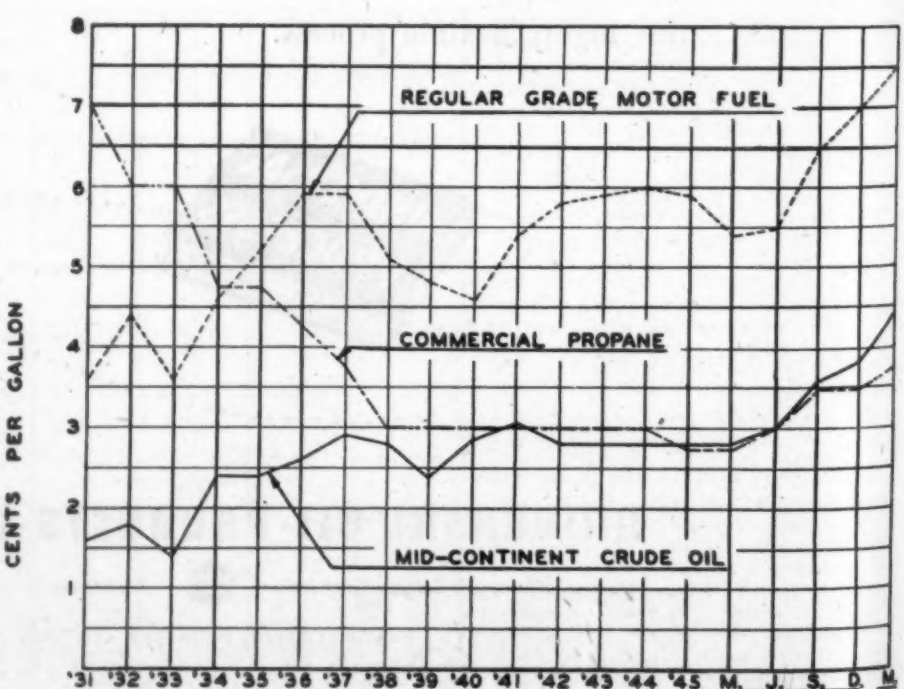

FIGURE 3

"Half-inch or Thirty!"

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at least 2 pounds. NGAA President, J. H. Dunn, commenting on the results to date, has stated:

"If the permissible vapor pressure of winter fuels can be raised by 2 pounds, it could easily mean that the northern motor fuel market would absorb more than 1,000,000 barrels of additional n-butane. It is also reasonable to conclude that spring and fall motor fuels of the same area could stand a 1 pound increase thus absorbing even more light ends from both the refining and natural gasoline industries."

About twice the volume of butane is used for motor fuel blending as the total volume of propane, butane and mixtures used by the entire liquefied petroleum gas industry in 1945. This quantity of butane is potentially available to the liquefied petroleum gas industry if the liquefied petroleum gas consumers are willing to pay the refiner more for the product than it is worth in motor fuel.

At present the liquefied petroleum gas industry has an unbalanced demand curve since there exists a severe winter consumption peak, due principally to the southern heating load. This situation makes it virtually impossible for a producer to handle the load of a gas utility requiring winter shipments for standby, peak shaving or supplemental gas purposes.

The gas utility concern contemplating the use of liquefied petroleum gas for peak load control should be prepared to receive and store during the period March 15 to November 15, any excess liquefied petroleum gas it expects to use in the period November 15 to March 15 above the quantity used each month of the year. For example, if the utility needs 150 car loads per month (5 cars per day or the equivalent of approximately 5,000,000 cubic feet per day of 1000 Btu gas) during the 4 winter months it should plan on using and/or storing during the other 8 months, 100 cars per month, say using 50 and storing 50 per month. Then 50 cars per month would be shipped each month during the winter and 100 cars per month withdrawn from storage. To store this quantity (600 car loads) would require 240—30,000 gallon gross capacity (25,000 gallons net) storage tanks; or if the utility chose to use 50 cars per month during the summer in order to secure delivery of a like amount per month in the winter only 160—30,000 gallon tanks would be required.

Standby Storage

At this point it is doubtless appropriate to mention that several companies are actively studying various means of storing large volumes of liquefied petroleum gas in order to seek the most economical way of providing utility concerns with adequate volumes of low cost liquefied petroleum gas for standby and supplemental gas purposes.

The following are some important factors which will affect the future price of liquefied petroleum gas to the gas utility.

1. Price of motor fuel.
2. Quantity of liquefied petroleum gas which can be blended in motor fuel.
3. Value of fuel oil to the refiner.
4. Technological improvements in processes for conversion of butane and propane into motor fuels and chemicals.
5. Changes in liquefied petroleum gas freight rates or costs of other forms of transportation.
6. Reductions in investment cost of pressure storage made possible by changes and improvements in design and construction.

Conclusion

The supply and demand outlook for liquefied petroleum gas may be summarized as follows:

1. An adequate supply of products appears to be available for anticipated developments. Those large consumers that have sufficient flexibility to permit use of propane or butane will be in a preferred position in securing adequate supply.
2. Transportation facilities are expected to keep abreast of future requirements, neglecting this coming fall and winter's expected tank car shortage due to continued delays in delivery of new tank cars. Except in a few special cases where pipe line or water movement can be utilized, transportation costs are expected to be as high or higher than at present.
3. Prices are expected to increase as increased demand can only be met by upgrading and diversion of the supply from present uses except, of course, supplies obtained from new oil fields. Any future increases in the price of crude oil will doubtless be reflected in the price of liquefied petroleum gas. Buyers that are in a position to take delivery of their annual requirements or a major portion thereof in the spring and summer should be able to buy at the lowest prices.

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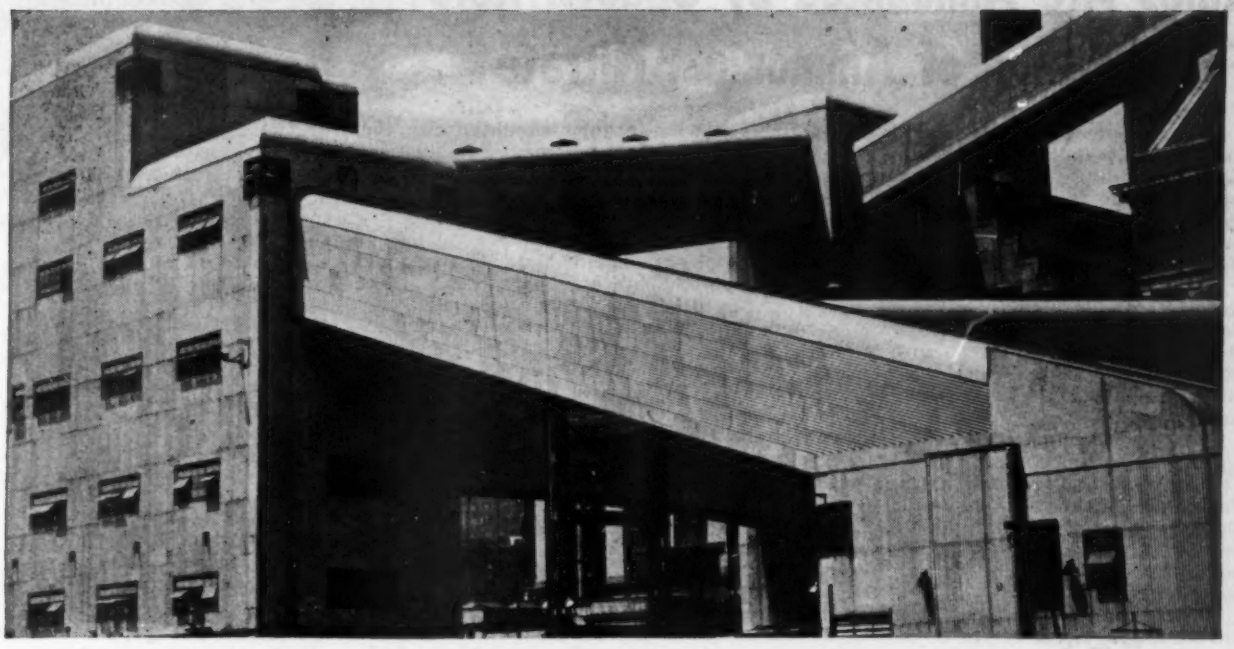

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THE MONTH IN THE INDUSTRY

Rules Are Announced by Underwriters For Handling of Ammonium Nitrate

Fourteen precautions that should be observed in handling and transporting ammonium nitrate are outlined in a joint report on the Texas City disaster released recently by the Fire Prevention Bureau of Texas and the National Board of Underwriters.

The report points out that the War Department Ordnance Safety Manual classifies ammonium nitrate as an explosive when it is stored with other combustibles in an explosive area. Smokeless powder regulations apply to ammonium nitrate.

"Proper labeling of containers is of utmost importance," says the report. "The label should be red in color with the words 'Hazardous Chemicals'—'Ammonium Nitrate'—'Handle With Care' prominently displayed with any other notations in small type, preferably of some other color."

The report points out that ammonium nitrate should never be stored in contact with carbonaceous materials or with cadmium, zinc, copper, tin or lead. It recommends also that it be kept apart from combustible commodities like sulphur, flour, sugar, compressed cotton and charcoal.

The fourteen recommendations of the two fire prevention organizations are:

Storage

1. Material should be stored only in masonry or fireproof sprinklered buildings.
2. Storage should preferably be in separate fire divisions from highly combustible commodities or well segregated.
3. Piles of ammonium nitrate in paper bags in storage should not exceed 10 bags high, six bags wide and 30 bags long with 3 foot separation between piles and handling aisles of 10 feet every 100 feet.
4. Spilled material from broken bags must be re-sacked immediately.

Handling

5. Ship's holds or boxcars must be thoroughly clean before loading operations are begun.
6. Spilled material in the hold, cars or on dock and discarded sacks must be removed immediately.
7. Proper dunnage and sweat-boards must be used in ship's hold and boxcars to prevent friction and to allow for circulating of air.
8. Smoking or the use of open lights *must be strictly prohibited* at any time.
9. Other cargo must not be placed in the same hold with ammonium nitrate.
10. Keep material clear of all steam lines and wiring.
11. Pending the outcome of tests now in progress, it is suggested that steam *not* be used for fire fighting in compartments containing ammonium nitrate.

Fire Fighting Operations

12. Any ship with ammonium nitrate entering a port must notify the port facility who in turn should notify the chief of the fire department immediately.
13. Fire departments combating ammonium nitrate fires should use only water in large quantities (applied gently so as not to scatter the material) as an extinguishing agent and all personnel entering the fire area must wear masks approved for use in such locations. Fire in ammouium nitrate usually generates large quantities of oxides-of-nitrogen gases which are extremely toxic.
14. Cities in which large industrial operations are present or which are in areas subject to hurricanes, earthquakes, tornadoes and other like disturbances should have a well preconceived and organized Disaster Plan to include all relief, law enforcement, fire fighting, military and naval agencies.

The report points out that the Department of Agriculture does not consider ammonium nitrate as explosive when it is stored in wooden containers or paper bags apart from other explosives. Addition of organic substances to prevent caking or cementing may act like a fuse, the report points out, and increase the possibilities of spontaneous combustion. The addition of other substances like super-phosphate and ammonium sulfate may act in the same way.

"Ammonium nitrate usually cannot be detonated by heat or friction," adds the report, "and it is comparatively insensitive.

"It may be exploded under favorable conditions by severe mechanical shock or by sufficiently heavy initiation of an intermediate explosive agent. Fertilizer piles containing this material should not be blasted. A shock may mechanically set up a chain of events which will result in the detonation of the entire mass of material."

The explosive factors of ammonium nitrate are effected by temperatures, crystal structure and impurities or extraneous matter. Numerous striking facts are reported in the illustrated 48-page printed booklet which is based on the data collected at Texas City by Dr. M. M. Braidech, director of research of the National Board, and Engineers Hugh V. Keepers and H. H. Davis of the Texas Bureau.

Address of the National Board of Fire Underwriters is 85 John Street, New York 7, N. Y.

Southwest Louisiana ACS Section Initiated

The new Southwest Louisiana Section of the American Chemical Society initiated on May 10 a type of technical meeting which may well become popular. Sessions included a variety of activities, but occupied only the one day, and were termed a "Meeting in Miniature." Headquarters for the occasion was McNeese Junior College at Lake Charles. Plant inspection trips were scheduled for the morning, and included tours of the Cities Service butadiene plant and refinery, the Firestone Tire and Rubber Company installations, the Continental Oil Company refinery, and the Mathieson Alkali Works. Luncheon was provided at the McNeese cafeteria.

The afternoon sessions included a general assembly, which heard expressions of welcome from Dean L. E. Frazer of McNeese College, an address by Sam H. Jones, former governor of Louisiana, and a technical discussion, "Chlorination," by H. B. Hass of Purdue University. A. R. Rescorla, chairman of the section, served as spokesman for the ACS group.

Balance of the afternoon was occupied with several panel discussions.

Conventions

June

23-25—American Chemical Society, Midwest Regional Meeting, Kansas City, Missouri.

September

15-17—National Butane-Propane Association, Jefferson Hotel, St. Louis.

17-19—National Petroleum Association, Hotel Traymore, Atlantic City, New Jersey.

29- 3—American Gas Association, San Francisco.

October

21-25—Pacific Chemical Exposition, San Francisco.

November

10-13—American Petroleum Institute, Stevens Hotel, Chicago.

Langsdorf Joins Staff of Oronite Chemical Company

Gaynor H. Langsdorf has been elected vice president and a director of Oronite Chemical Company, San Francisco, subsidiary of Standard Oil Company of California. He will have charge of products and services. Previous to the change he was manager of technical services in the manufacturing department of the parent company.

In his new position, he will be responsible for activities relating to manufacturing, research and product development. He also will act in a liaison capacity in these matters with Standard and its research subsidiary, California Research Corporation.

Milton L. Baker will continue as Vice President in Charge of Sales and related activities.

In another change, Norman N. Gay, previously Manager of Oronite's product development division, has been transferred to the special products division of Standard Oil Company of California.

Langsdorf was graduated from the University of Washington, in 1930 with a B.S. degree in chemical engineering. In 1932 he obtained his M.S. degree in chemical engineering practice at the Massachusetts Institute of Technology.

Underground Gas Storage Gets Commercial Application

National Tube Supply Company, a U. S. Steel subsidiary is collaborating with The Public Service Company of

Go "National" for Lead VALVES

What kind of Acid Valve do you need?

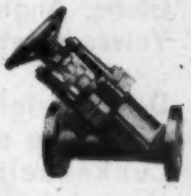
1 "United" Type R Valve? This ingenious valve, recently introduced by National Lead, offers advantages unobtainable with valves whose body and seat are cast as an integral unit. Because of its split-body construction it can be installed either as a "Y" or Angle pattern. All you do is reverse the position of the body section, as shown in the illustrations below. Thus, your supply stock can be held to a minimum by standardizing on *one* valve with *two* uses. Another feature is the removable seat and plug disc. Both can be replaced easily at nominal cost. Finally, seat and plug can be supplied in any alloy or material you specify. For normal applications, the valve is furnished in three standard ways: 1. Lead plug disc and stem integral; 2. Removable lead plug disc; 3. Removable rubber plug disc.

Two valves in one! *Simply reverse the position of the body sections and the "United" Type R Valve is changed from a "Y" pattern to an Angle pattern. Available in hard lead or lead-lined cast iron or cast steel.*

2 "United" Chem-Rayon Valve? This valve is manufactured in both "Y" and Angle design. The body is cast hard lead. Fins of the same metal reinforce and greatly increase the strength of body and flanges, while holding weight to a minimum. The stuffing box is of exceptional depth. Packing can be replaced under pressure. Steel and bronze bonnet are completely covered (except wheel and bushing) with hard lead. Available with removable plug discs of rubber or lead.

We also supply check, foot and diaphram valves in hard lead, cast iron, and cast steel lead lined.

3 "United" Type C Valve? The important difference between this type and the "United" Chem-Rayon valve is in the materials used for the body and bonnet. In the Type C valve these are made of cast carbon steel or cast iron heavily lined with lead. Furthermore, the body is cast oversize in order to allow a full flow area after lining. All parts of the two valves are interchangeable. Available in both "Y" and Angle patterns.



4 "United" Gate Pattern Valve? This is a most efficient gate valve, available with body and bonnet in hard lead, lead-lined cast steel or lead-lined cast iron. It is designed for use wherever an absolutely drip-proof acid valve is a "must." The seat is hard lead, cast integral with the body lining. This valve can be furnished with disc made of acid-resisting rubber, bakelite, or special alloys as required. You get a satisfactory seal at all times.

No Matter what Your Acid-handling Problem . . .

Go "National" for Lead

National Lead is ready to consult with you and supply any type of lead pipe . . . valves . . . sheet . . . lead-lined or lead-covered equipment . . . even complete acid recovery plants. And behind every National Lead product, every National Lead recommendation, are years of experience and many important installations in every field handling corrosive liquids and gases.

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Specify LUNKENHEIMER N-M-D VALVES

400 lb. W.O.G.

● For Liquefied Petroleum Gases . . . in LP-Gas systems, bulk transfer and storage tanks, domestic cylinder charging manifolds, vapor differential compressors and general industrial uses . . . Lunkenheimer 400 lb. W.O.G. Globe, Angle and Check Valves meet every need.

Designed for this particular service and reflecting Lunkenheimer Quality throughout, these rugged valves have special packing and a special, easily renewable non-metallic disc. They seat tight and stay tight.

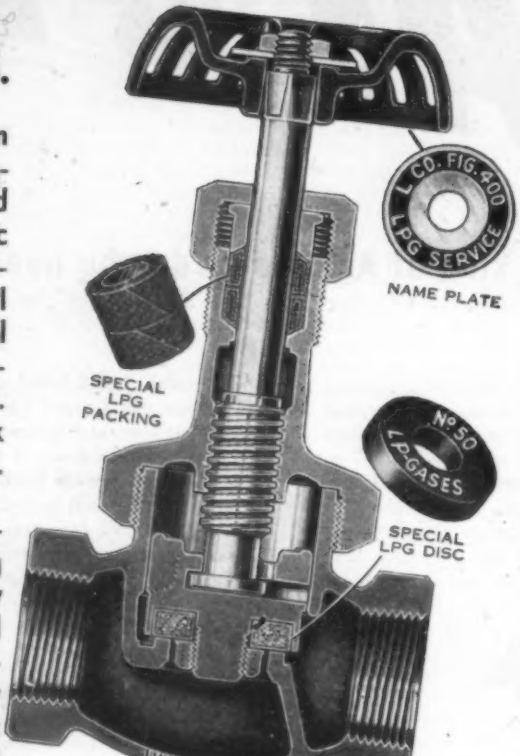

FIG. 400

No. 400 "N-M-D" Valves conform to all requirements covering the use of high pressure, liquefied petroleum gases.

ASK YOUR LUNKENHEIMER DISTRIBUTOR

Write for Bulletin 576, or ask your distributor for a demonstration of Fig. 400 "N-M-D" Valves for Liquefied Petroleum Gases. Lunkenheimer Distributors are located in oil producing and refining centers.

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LUNKENHEIMER VALVES

BRONZE, IRON, STEEL, AND CORROSION RESISTANT ALLOY VALVES
AIR DEVICES, LUBRICATORS, AIRCRAFT FITTINGS

THE MONTH...

Northern Illinois in a project that some experts believe will revolutionize the natural gas storage field. Briefly the project provides for gas storage underground rather than in the conventional storage tanks above ground and utilizes large diameter seamless steel pipes arranged in fields at rather close spacing.

Last fall the utility company completed a pilot installation of subterranean gas storage at Kankakee, Illinois, and presently is constructing a commercial installation on a 160-acre tract at Mount Prospect, Illinois, that is nearly forty times as large as the Kankakee plant. National Tube built the high pressure torpedo-like steel pipe sections for the Kankakee project and is now furnishing the underground pipe for the Mount Prospect installation.

At Kankakee the pilot plant has a capacity of 1,250,000 cubic feet of gas, while at Mount Prospect the finished project will have a capacity of 40,000,000 cubic feet.

Steps in the development of the new storage method included preliminary tests of pipe installations, construction of the pilot plant at Kankakee. Final testing with air before actual introduction of gas, filling of the sections with natural gas under pressure to place the plant in initial operation. It has been in successful use since November.

The pipe sections for the underground gas storage program are fashioned from 24-inch seamless molybdenum steel pipe, with ½-inch wall thickness. Each pipe section is 40 feet long with a capacity of 25,000 standard cubic feet at 2240 pounds pressure, and is nosed in at the ends and machined for connection. The pipe sections are buried many feet underground.

The utility company reports that underground gas storage primarily has a lower cost of initial installation, and secondly, a lower cost for operating and maintenance than conventional gas holders. A point in favor of the underground system, the utility company said, is that since storage is in numerous small units, storage capacity may be added easily or any unit may be taken out of service for repair or inspection without disturbing others. Inasmuch as the installations are subterranean, above-ground hazards are eliminated.

WPRA Meeting Dates

The board of directors of the Western Petroleum Refiners Association have selected Galveston as the location for the 1948 annual meeting which will be held on April 5, 6, and 7. Headquarters for the meeting will be the Galvez and Buccaneer hotels.

Old Ocean Plant Sold

Alamo Refining Company will put the war-built refining plant at Old Ocean, Texas, back in operation within three months. The 25,000 barrel plant was bought last month from War Assets Corporation. The plant has been idle since the end of the war. It was operated as a unit in the 100 octane aviation gasoline program by J. S. Abercrombie, Harrison Oil Company.

The new company was formed by

B-H No. 1 Insulating Cement makes it easy to keep BTU's where you want them

Here's the fast, efficient way to prevent fuel waste through the surface of valves, fittings and other irregular surfaces.

Fast—because you simply add water, mix and apply. B-H No. 1 sticks instantly—won't slide off bottom surfaces or roll up behind the trowel.

Efficient—because it's compounded of *Black* Rockwool—insulates up to 1800°F. For example, a 3-inch application reduces 800°F. surface temperature to 150°F.

Other advantages: B-H No. 1 doesn't crack or peel. A special rust inhibitor safeguards against corrosion, assures a permanent bond. Reclaimable up to 1200°F.

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THE MONTH . . .

Phillips Petroleum Company, H. A. Grebe, former superintendent at Old Ocean, E. P. Doremus, former chief chemist there, and other interests. Grebe and Doremus now have a consulting firm in Houston and do not anticipate returning to the plant, where operating personnel is expected to get its top men from the Phillips organization.

Rehabilitation will convert the isomerization unit into a polymerization unit. The alkylation unit may not be operated. Other units are the crude stabilization, straight distillation, fluid catalytic cracking and reforming. The plant was the only complete refinery built during the war program as a government-owned venture.

J. M. Graham Shifted to Monsanto Process Section

J. M. Graham, Jr., formerly Assistant Director of the Monsanto Chemical Company's General Development Department, has joined the General Engineering Department as Manager of the Process Section, and H. T. Gammon has returned to his former post as Manager of the Project Analysis Section, the company announced today.

Most of the chemical engineers now associated with Graham in the Development Department will move with him to form the nucleus of a group which will be needed to, as necessary, to handle a broad chemical engineering program.

The Process Section will do the chemical engineering work necessary for the projects handled by General Engineering, and upon request will also be prepared to handle detailed chemical engineering work necessary for the evaluation of new projects under study by the divisions and other staff departments.

Graham was graduated from the University of Virginia in 1927 and joined Monsanto as a junior research chemist in 1934, advancing to research chemical engineer and chief chemical engineer of the Phosphate Division, before joining the General Development Department as principal project engineer in 1945.

Petroleum Base Cutting Oils

A new line of cutting oils which prevents discoloration during the machining of high-conductivity, oxygen-free copper for electrical equipment has been announced by the Socony-Vacuum Oil Company, Inc., The new oils are produced in two grades—one for high-speed operations, such as automatic screw machines, and the other as a replacement for and possessing the same viscosity as lard oil. Choice is governed by cutting speeds of the machining equipment, according to Socony-Vacuum's Technical Division.

The oils were developed for machining of alloys containing more than 60 percent copper and are adapted especially to such operations as drilling, tapping, threading and trimming of copper and copper-alloy parts. In addition, they can be used in drawing and press-forming operations.

John F. Lynch Heads La Gloria Corporation

John F. Lynch, who had been vice president, has been elected president of La Gloria Corporation, Corpus Christi, to succeed the late Robert T. Wilson. Other officials elected at the meeting of directors are P. R. Hass, vice president and treasurer; D. Philips, secretary; T. E. Wilson and H. G. Nebeker, assistant secretaries.

JOHN F. LYNCH

P. R. HAAS

This action of the directors followed a meeting of stockholders, who had elected the following directors, C. E. Wilson, John J. Sherrin, T. E. Wilson, E. F. Johnson, Binford Arney, Guy C. Kiddoo, John F. Lynch, T. S. Scibienski and P. R. Haas.

Lynch is a director of Carthage Hydrocol, Inc., which is building a plant near Brownsville for the conversion of natural gas into motor fuel and other liquid products. La Gloria Corporation is a stockholder in Carthage Hydrocol. Lynch also is president of Reynosa Pipe Line Company of Corpus Christi.

Properties of Sulfur in Petroleum Compiled

Based on cooperative work between the United States Bureau of Mines and the University of Wyoming, a new publication now available for free distribution to the industry lists the boiling points, freezing points, densities, and refractive indices of more than 300 sulfur compounds.

Although the bureau is conducting related work on the identification of sulfur compounds in petroleum, the material was compiled in table form from available literature by William E. Haines, Welton J. Wenger, and R. Vernon Helm, petroleum chemists, and John S. Ball, refinery engineer, all of the bureau's petroleum and oil-shale experiment station at Laramie, Wyoming.

Describing some of the forms of these materials, the bureau report also discusses the nomenclature of sulfur compounds in petroleum. A copy of the publication, Report of Investigations 4060, "Sulfur in Petroleum; II. Boiling Points, Freezing Points, Densities, and Refractive Indices of Some Sulfur Compounds," may be obtained by writing to the Bureau of Mines, Department of the Interior, Washington 25, D. C.

Gulf Publishing Company Officials Are Re-elected

The following officers of The Gulf Publishing Company were elected at a recent meeting of the company's Board of Directors: Ray L. Dudley, president; A. L. Burns, vice president and general manager; Tom W. Nelson, second vice president; R. P. Swinsky, vice president; Warren L. Baker, secretary; L. J. Logan, assistant secretary; P. J. Aucoin, treasurer; and Robert V. Turner, assistant treasurer.

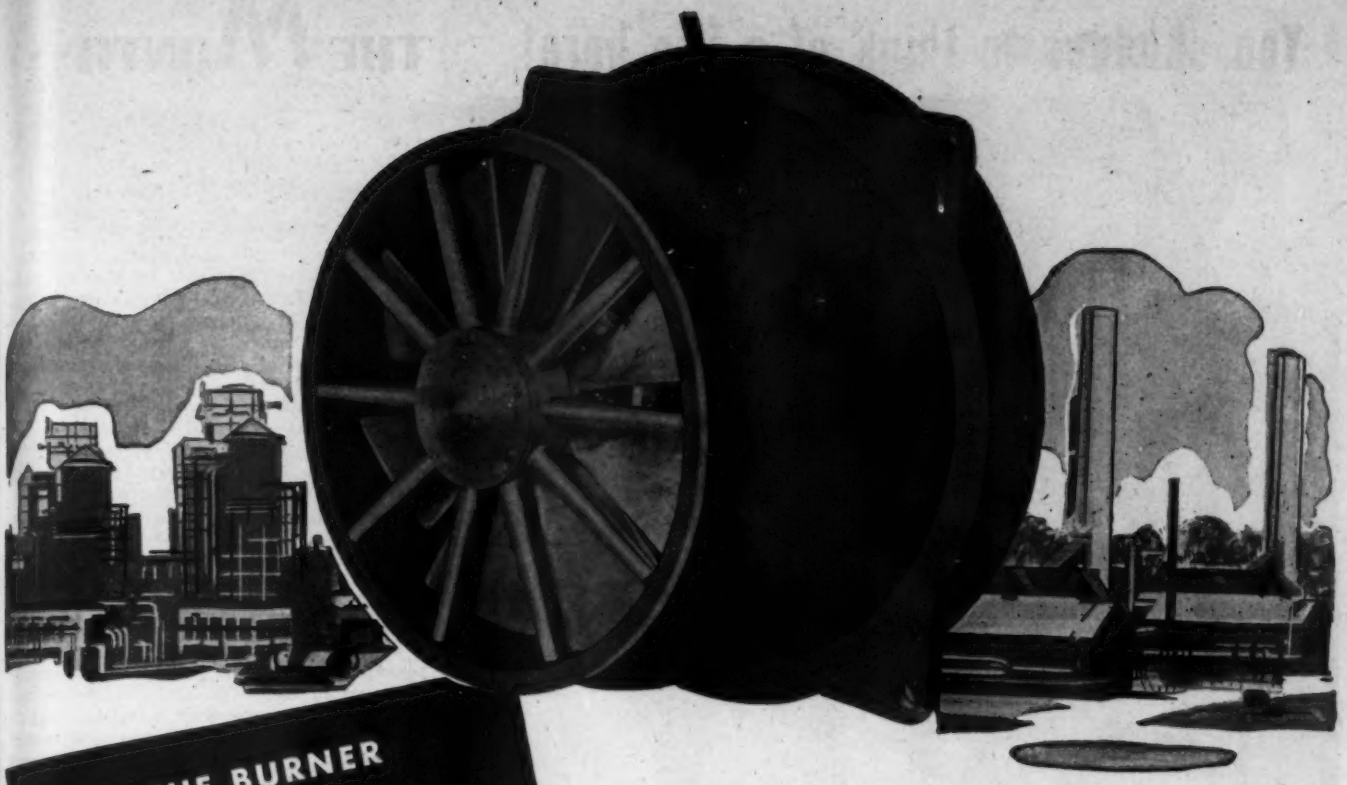
At the company's annual stockholders meeting, which immediately preceded the board meeting, the following were elected directors of the company: Ray L. Dudley, James Anderson, Charles H. Lane, A. L. Burns, T. W. Nelson, Warren L. Baker, William Hudspeth, R. P. Swinsky, and P. J. Aucoin.

Cities Service Expands Gasoline Facilities

An intensive modernization and expansion program that will greatly increase manufacture, handling and storage of liquefied petroleum gases and chemicals, is underway at 10 plants of the Cities Service Oil Company.

In Oklahoma, Cities Service has consolidate the Jones and Bodine plant facilities, with the Bodine plant processing all gas gathered in the big Oklahoma City field. Yard piping at the Bodine plant has been completely revamped and streamlined, with some rearrangement of processing equipment to further increase plant efficiency.

The Tallant, Oklahoma chemical plant, where processing requirements had outpaced steam generating capacity, is now being equipped with electrification for all pumping equipment. In working out the changeover in power, decision was made to simplify the piping arrange-



THE BURNER that makes a new Boiler EASIER TO BUY

***Thorough, accurate mixing of fuel and air . . . complete combustion . . . with Coppus-Dennis* FANMIX**

When planning new gas or oil fired boilers, you can count on investing less in boiler, stack and auxiliary equipment — if you select a Coppus-Dennis FANMIX Burner. Coppus equipment was used for instance in 93% of 191 petroleum refinery plants built for war use.

FANMIX Saves Combustion Space

FANMIX delivers to the furnace a homogeneous mixture of fuel and air, without blow-torch action. Combustion is rapid and complete — so smaller combustion space is needed than when the furnace must serve as mixing chamber as well — or ratings of present equipment can be increased.

FANMIX Creates Own Forced Draft

Less furnace draft is needed than with any other burner, because FANMIX creates its own forced draft, thus overcoming draft loss across the burner (at any operating range). Less stack is needed, and forced draft equipment can be eliminated entirely.

There are two FANMIX types—one to handle natural gas, the other a combination type to burn either gas or oil in entirety or gas and oil in any proportion. (No oil guns needed).

Coppus engineers FANMIX Burners for individual applications. Complete control over rate of combustion or "flame pattern" can be provided to meet the requirements of any installation. Coppus Engineering Corporation, 246 Park Ave., Worcester 2, Mass. Sales offices in THOMAS' REGISTER. Other Coppus "Blue Ribbon" products in SWEET'S, CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG.

New Bulletin Will Help You When Installing New Equipment or Modernizing Old

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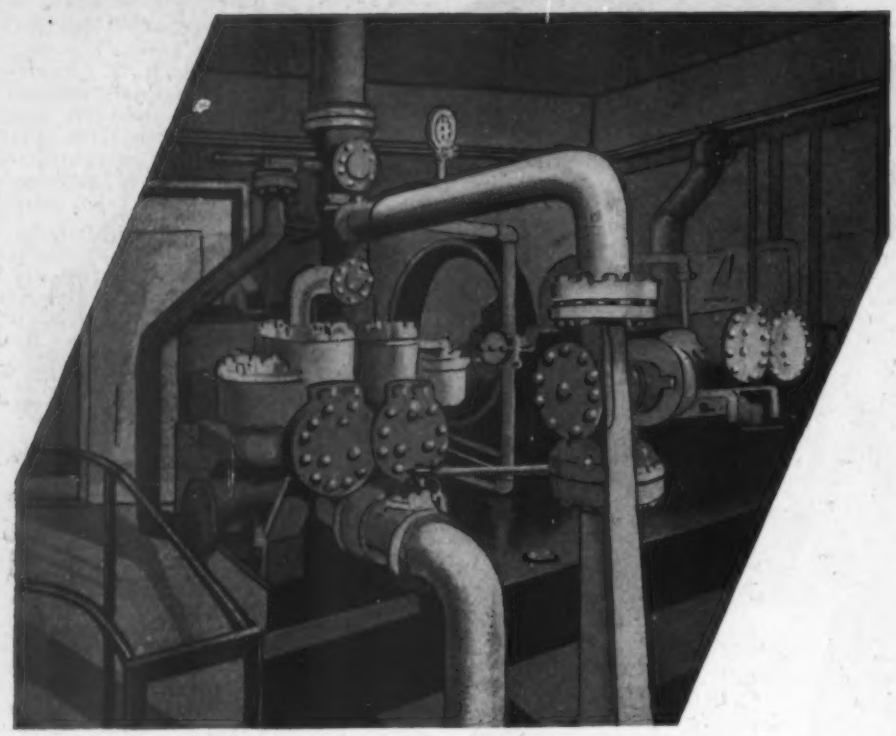
You shudder to think of a fire here!



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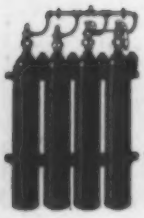
C-O-Two

PUMP rooms, solvent extractors, de-waxers, laboratories, stills—any area in your plant where petroleum is processed —call for quick fire detection and extinguishing. A C-O-Two Automatic System gives you this *complete* protection. The moment fire starts, a rate-of-rise or fixed temperature detector operates the system. Before damage is done, the fire is blanketed in clouds of cold, dry carbon dioxide gas-and-snow. Out in seconds!

C-O-Two is clean, modern fire protection. It is especially suited for petroleum and other flammable liquid fires. Can be used on running electric equipment because it's non-conducting. C-O-Two never corrodes metals or damages delicate instruments. When the fire is out, C-O-Two disappears without a trace.

Let an expert help you plan your fire protection. Write us for more information about C-O-Two today.



C-O-TWO FIRE EQUIPMENT COMPANY

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Sales and Service in the Principal Cities of United States and Canada

AFFILIATED WITH PYRENE MANUFACTURING COMPANY

THE MONTH . . .

ment to conserve space, reduce pressure drops and to provide more adequate cooling for both the chemical refinery and the gasoline plant.

In Kansas, Cities Service has consolidated the Burrton and Stone gasoline plants, the Stone plant being converted to a booster station, to be run in conjunction with the Burrton gasoline plant.

Changing the engine jacket water system to a closed water system, which will enable more efficient operation of engines and a reduction in maintenance costs, is underway at the Button, Kansas chemical plant. Revamping of the process cooling water system will provide increased cooling capacity and will result in greater products recovery.

The Arkansas City, Kansas plant has been completely modernized, with storage facilities for LPG increased by the addition of two 30,000-gallon tanks. Tank car loading facilities have been installed as a part of the program.

Modernization at the Odessa gasoline plant, West Texas, calls for the installation of an 800 h.p. angle-type engine-driven compressor with auxiliary equipment. In addition to the increased horsepower, the present gathering system will be revamped and extensions made for connection of additional field wells.

Replacement of obsolete equipment at the Pampa, Texas plant is included in the modernization plan. This includes modern facilities and improvements in the cooling system. In addition to its previous production of butane the Pampa plant will turn out propane. Additional storage facilities are being built to take care of increased production.

Due to increased demands for LPG products in the Great Lakes area, Cities Service has started an enlargement program at the recently-constructed terminal at Green Bay, Wisc. Capacity will be increased from 117,500 barrels to 252,000 barrels. An 80,000-gallon storage tank has already been installed, and work has begun on an additional 50,000-gallon tank.

War Plant Disposal

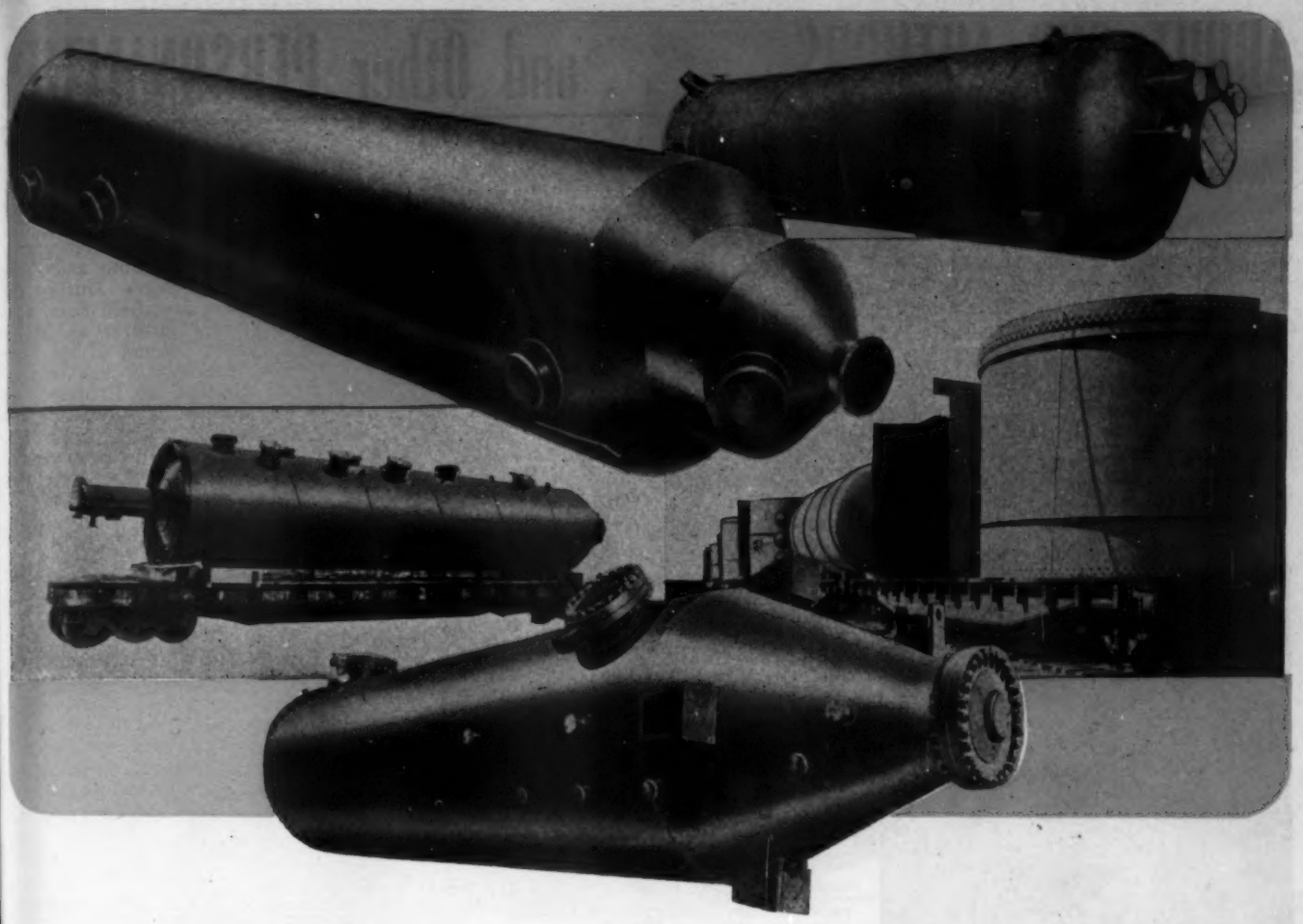
Root Petroleum Company has bought the catalytic cracking unit and other facilities for making 100 octane aviation gasoline at its plant at El Dorado, Arkansas, for $5,979,224.

Wartime facilities at Richmond, California, operated during the war by Standard Oil Company of California and since then under a lease, will be sold June 21. A TCC catalytic cracking unit, HF alkylation unit and an isomerization unit are included in the properties built at a cost of $21,214,000.

The fluid type catalytic cracking unit and other facilities for making high octane gasoline, operated by Eastern States Petroleum Company, Houston, have been declared surplus by War Assets Corporation and will be offered for sale.

1948 Natural Gas Meeting

The Natural Gas Department of the American Gas Association has selected Houston, Texas, on May 4 and 5, for the place and time of its annual spring meeting in 1948.



PICTURE OF A PENNY SAVED

For as many years as General American has been designing and fabricating process equipment for the Petroleum Industry, a penny reduction in the retail price of gasoline has been headline news.

The comparatively low cost of American petroleum products is due as much to high efficiency, low-cost production as to our abundant natural resources.

For years General American has been precision fabricating pressure vessels and equipment to handle the various gases, liquids and bulk materials used in the Petroleum Industry.

No picture of cost reduction in this great industry is complete without giving consideration to the part played by General American Process Equipment behind that achievement.

Other General American Equipment

TANKS . . .
Crude • Gasoline • Propane
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ABOUT OUR AUTHORS . . . . . and Other PERSONALITIES

Marek Moves Up

Election of LeRoy F. Marek as vice president of Arthur D. Little, Inc., Cambridge, Massachusetts, recalls that he was one of the authors of the War Products issue of PETROLEUM REFINER, October, 1942. Marek summed up the development of chemical rubber under the title, "Notes on the History of Synthetic Rubber."

Marek has been on the staff of this outstanding industrial research organization since 1934 and for several years has been in charge of its chemical engineering division.

LEROY F. MAREK

He is a native of Texas and a graduate of the University of Texas. After undergraduate work at Austin he took his master's degree at Massachusetts Institute of Technology and served on its staff as acting director of the research laboratory of applied chemistry before joining the Arthur D. Little staff.

Postman's Holiday

Now that Mrs. Isabella Brokaw Wallace has retired as librarian in the Whiting laboratories of Standard Oil Company (Indiana), she will establish her own consulting library and research service, which will provide translations from French and German literature.

In her 22 years in the Whiting laboratories she had been instrumental in building up one of the outstanding classifications and indexing systems in petroleum circles. Previously she was with the Newberry library in Chicago and had been with a New York patent legal firm, a chemical company in Buffalo. She is a graduate of Olivet College,

ISABELLA BROKAW WALLACE

and had special training in Library Science at the University of Illinois.

Her professional activities include memberships in the American Library Association, the Indiana Library Association and has served as president of the Illinois chapter and as national chairman of the Special Libraries Association. She is a past president of the Whiting Business and Professional Woman's Club.

As To Corrosion . . .

In the concluding paragraphs of his series, "Corrosion Studies for the Petroleum Refining Industry," which starts with this issue of PETROLEUM REFINER, F. A. Rohrman makes in brief, the following observations:

"A corrosion expert is constantly deluged with requests for advice on corrosion prevention or corrosion expectancy. In general, these queries attempt to establish conditions under which a material will be exposed or has suffered. Any sane advice to solve such problems must assume a broad knowledge of the many factors which might be responsible for or influence corrosion. One must know, for example: that crude phosphoric acid is usually contaminated with fluorides, that some soils are hundreds of times more corrosive than other soils, that condenser cooling waters offer excellent environments for thermophylic organisms, that under many conditions electropositive elements will corrode in the presence of electronegative elements."

Acquiring "broad knowledge," in the case of this particular corrosion expert, has involved extensive academic training and wide variety of professional experience. Rohrman was born in Oregon, obtained a bachelor of science degree at Oregon State College in 1926, a master of science degree from the University of Minnesota in 1928, and his Ph.D. at Columbia University in 1931. He taught at the Michigan College of Mining and Technology for some ten years. During the war period he went far afield from academic routines, serving first as Major and later Lieutenant Colonel of the Field Artillery. Since the war he has been at Kansas State College as Professor of Chemical Engineering and head of the Chemical Engineering Department. Recently he has been appointed executive director of the Engineering Experiment Station of Colorado University at

F. A. ROHRMAN

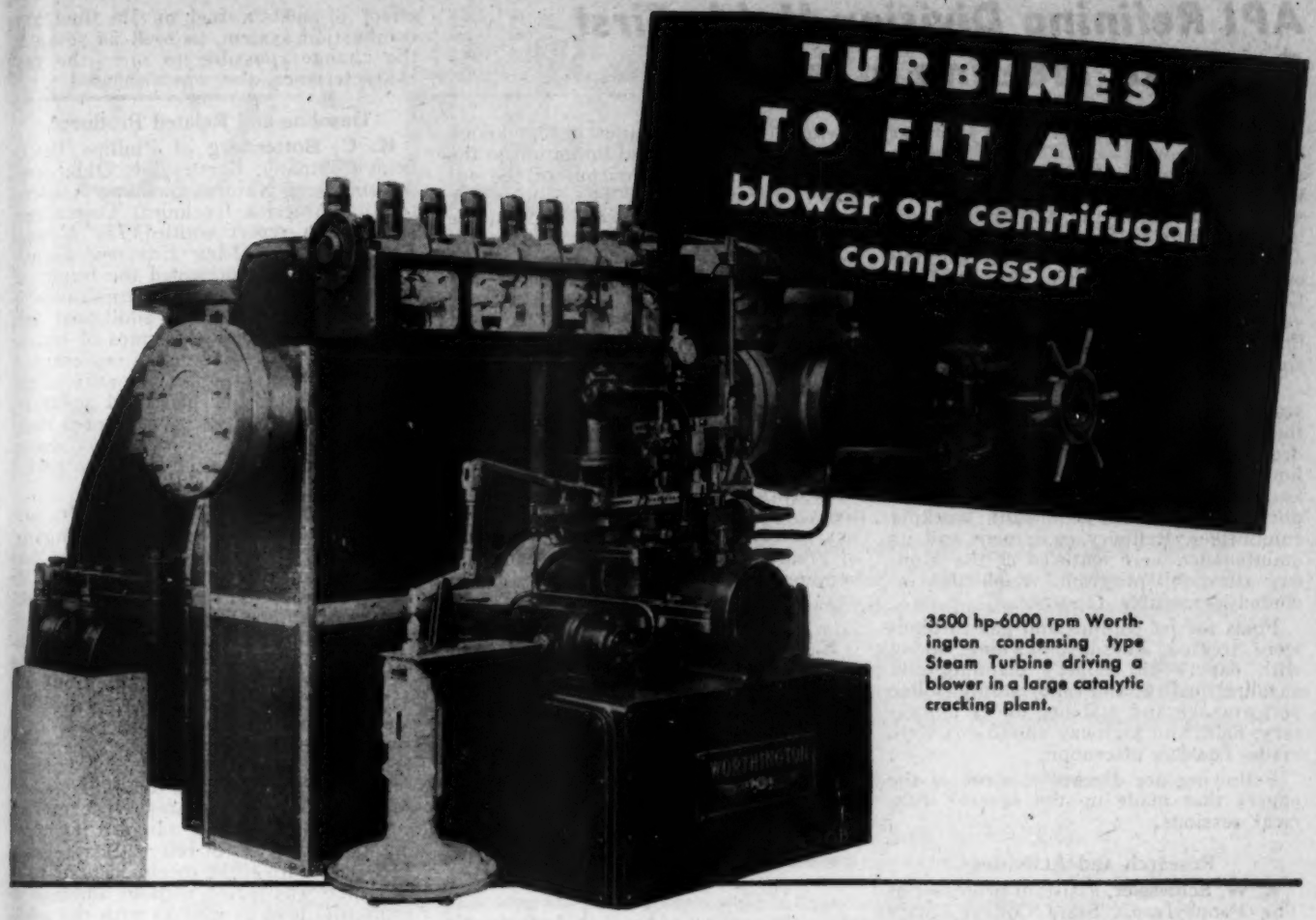
Boulder, which post he is to assume July first. Rohrman is a member of the A.I.Ch.E., A.C.S., N.A.C.E., A.S.E.E., and the Kansas Academy of Science, and has, in addition, published some thirty-six different papers, and holds several patents.

Staff Changes

In the reorganization of the editorial staff of PETROLEUM REFINER following the death of J. Kent Ridley, managing editor, May 12, Silas B. Ragsdale, news editor of THE OIL WEEKLY, has taken over in that position.

L. S. Daniels had been promoted to editor May 1, upon the resignation of Grady Triplett. C. C. Pryor, associate editor, who previously had devoted all of his attention to cycling and natural gasoline activities will now take on some of the developments within the refining industry itself.

Pending familiarity with their expanded duties, Grady Triplett has agreed to give the staff time in a consulting capacity for as long as needed.



3500 hp-6000 rpm Worthington condensing type Steam Turbine driving a blower in a large catalytic cracking plant.

A 20,000 hp Worthington Steam Turbine is now being built for a centrifugal compressor drive

More and more refineries are getting more horsepower from less steam, because their blowers and centrifugal compressors operate at high efficiency with Worthington Steam Turbine Drives.

Whatever the type your plant demands... straight condensing, straight non-condensing, bleeder, mixed pressure, mixed pressure bleeder, low pressure or high back pressure.. there's a Worthington Turbine unit available. Worthington engineers, drawing on their rich experience in developing blower and compressor drives, offer you the variety of frame sizes that assures the *right* unit for *your* requirements.

For further proof... in steam turbines as in so much other equipment... *there's more worth in Worthington*, write for information. *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N.Y.*

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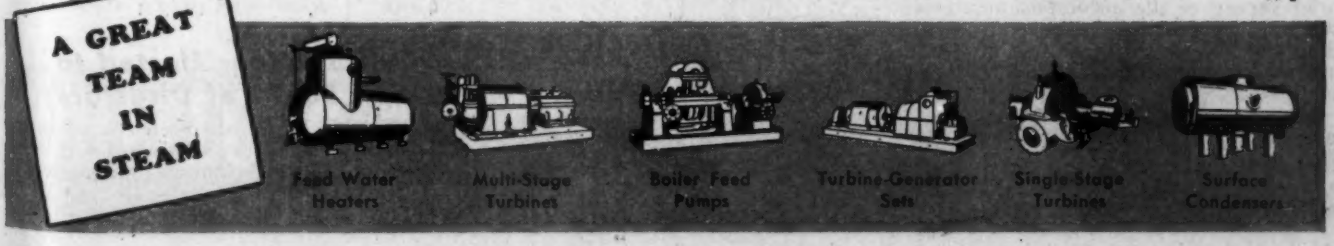

API Refining Division Holds First Post War Meeting in St. Louis

Consideration of fuels for all types of airplanes as well as for motor vehicles were a part of the technical sessions of the first mid-year meeting of the Division of Refining of the American Petroleum Institute in St. Louis, June 2 and 3. There was an open dinner meeting the evening of June 2 when Arthur Holly Compton, chancellor Washington University, St. Louis, and Ralph C. Champlin, Ethyl Corporation, New York, were speakers.

The Monday morning session on research heard papers and discussions on the synthesis and properties of rare hydrocarbons; the components of gasoline; the relationship between engine knock and molecular structure, and reports from seven important working committees. Refinery equipment and its maintenance were featured at the Monday afternoon program, which also included committee reports.

Fuels for jet engines and gas turbines were treated Tuesday morning, along with papers on refinery planning and gasoline quality; and reports on gasoline performance and stability under laboratory, field, and highway conditions were made Tuesday afternoon.

Following are digests of some of the papers that made up the several technical sessions.

Research and Activities

R. W. Schiessler, assistant professor at The Pennsylvania State College, State College, Pa., presented a report entitled *The Synthesis and Properties of Hydrocarbons of High Molecular Weight—IV,* a joint effort by himself and C. H. Herr, A. W. Rytina, C. A. Weisel, F. Fischl, R. M. McLaughlin, and H. H. Kuehner. The paper covered a small portion of the work reported in the complete paper—a section dealing with the effect of chemical structure on the properties of mixtures of pure hydrocarbons in the lubricating-oil range. The research discussed revealed an interesting relationship between the physical properties of mixtures and the hydrocarbon groups which make up the molecules of which the mixtures are composed. The effect of saturated groups was shown to be markedly different from comparable aromatic structures.

Cecil E. Boord, of The Ohio State University, Columbus, Ohio, spoke on *The Components of Gasoline.* His paper was in the nature of a summary and progress report to the Division of Refining on API Research Project 45. It contained: 1) a brief historical résumé of the growth and development of the project and its relationship to the other projects of the Division of Refining; 2) a description of the work of the project and its method of operation; 3) a discussion of the synthetic procedures used, i.e., illustrated by selected typical examples; 4) a brief survey of the accomplishments of the first nine years of the project's operation; and 5) a forward look, viz., projecting the possible future development of such work over a period of several years.

Wheeler G. Lovell of General Motors Research Laboratories, Detroit, spoke on *Engine Knock and Molecular Structure of Hydrocarbons,* in which he said that the reason for the interest in the knock behavior of fuels in engines is that knock stands as a fundamental limitation to the efficiency and power output of the engine-fuel combination. The work done under API Research Project 45 on the measurement of the knock behavior of the pure hydrocarbons as prepared at The Ohio State University and tested at the General Motors Corporation and Ethyl Corporation laboratories has provided the petroleum and automobile industries with an extensive fundamental background of how the various types of fuel hydrocarbons behave in engines. The enormous amount of data obtained in this endeavor has made it possible to correlate the molecular structure of hydrocarbons with knock ratings, sensitivity, and lead susceptibility. The practical economic gains to be had with fuels of greater freedom from knock may be very great.

Equipment and Activities

E. W. Stothart, manager of the pipe suspension department for Grinnell Company, Inc., Providence, Rhode Island, spoke on *The Importance of Flexible Pipe Supports.* He said that, when flexible supports are used, the transfer of weight from one hanger to another may be the cause of an additional type of stress that is very hazardous to the entire refinery. The relative importance of these weight-transfer stresses was compared to the values of recognized total pipe stress in a typical piping system. He attempted to show that spring hangers that are merely designed for thermal movement to take place are inadequate.

Gasoline and Related Products

A. P. Frame of Petroleum Advisers, Inc., New York, in speaking on *A Refiner's Look at Gasoline Quality* said that gasoline quality has been, and will be, determined by the ability of the refineries to produce quality and then the automotive engineers to design the engines to utilize the higher-quality fuel generally available. Due to wartime installation of refining facilities for the production of high-quality gasoline, principally 100-octane aviation gasoline, and the announced postwar construction of such facilities, more than 50 percent of the refining capacity in this country will be equipped to produce, no later than 1950, house-brand gasoline of 79 ASTM and 85 research octane numbers, as well as premium gasoline at 84 ASTM and 94 research octane numbers. It is, therefore, believed that such quality will be the average competitive quality of motor gasoline by 1950. This quality gasoline will penalize refineries without catalytic cracking facilities; but, despite individual hardship cases, the ever-increasing quality of gasoline has contributed to the growth and well being of the petroleum and automotive industries as well as the country as a whole and is, therefore, economically justified.

A. J. Nerad of General Electric Company, Schenectady, New York, spoke on *Fuels for Jet and Gas-Turbine Engines,* saying that the likelihood of an expanded use of such fuels requires that their availability be seriously considered. A volatile fuel of high aromatic content was proposed as an available fuel. The effect of such a fuel on the fuel and combustion system, as well as some of the changes possible to meet the fuel characteristics, also was discussed.

Gasoline and Related Products

K. C. Bottenberg of Phillips Petroleum Company, Bartlesville, Oklahoma, on behalf of Natural Gasoline Association of America Technical Committee, presented a report entitled *The Nowata Road Tests and Their Economic Significance.* His paper presented the results of the tests, their economic significance in terms of permissible additional fuel volatility—giving the volumes of butane and other light components represented, as well as the states and months of the year in which the increased volatility can be applied. Extensive average daily maximum temperature data was shown by months and by states for the period 1916 through 1935.

E. M. Barber, L. E. Endsley, Jr., and **T. H. Randall,** of The Texas Company, New York, gave a report on *Some Characteristics of Combustion in the ASTM-CFR Knock-Test Engine.* This showed the results of an engine-performance type of investigation of the ASTM-CFR knock-test engines as they are operated on the ASTM and CFR research methods for octane-number determination. The measurements included air and fuel consumption of the engines, the power developed while rating fuels, the fuel-air ratio at which fuels are rated, as well as sets of indicator diagrams. Observations covered the defined range of octane number from 0 to 100 with reference fuels and with eight specimen fuels each of which was tested without addition of tetraethyl lead as well as with the addition of 3.0 ml of tetraethyl lead per gallon. The results were summarized on the charge-density vs. charge-temperature coordinates to bring out the temperature-sensitivity aspect of the difference between octane-number tests by the two methods and as a basis for considering correlations between the octane-number tests and the performance of fuels in service engines.

E. L. Walters of Shell Development Company, Emeryville, California, presented a report entitled *Correlation of Accelerated and Laboratory Storage Measurements for Gasoline Stability with Field Stability — 1943-45 CRC Desert Storage Tests on 80-Octane All-Purpose Motor Fuel,* in which he said that storage requirements for motor fuels in wartime were considerably more severe than normal peacetime levels. In 1942 Army Ordnance requested CRC assistance in determining the best practical methods for predicting gasoline stability under the more severe storage conditions then required. Industry background permitted immediate recommendations on a best-guess basis: but these required subsequent verification by correlation with actual field tests. This paped reviewed the three extensive series of tests in which accelerated oxidation tests were correlated with field and laboratory storage. The results are of distinct interest in connection with all aspects of motor-gasoline stabilization

Carl S. Miner Elected to UOP Board of Directors

Carl S. Miner has been elected to the board of directors of Universal Oil Products Company, Chicago. A native of Iowa, Miner attended Coe College, Cedar Rapids, and the University of Chicago

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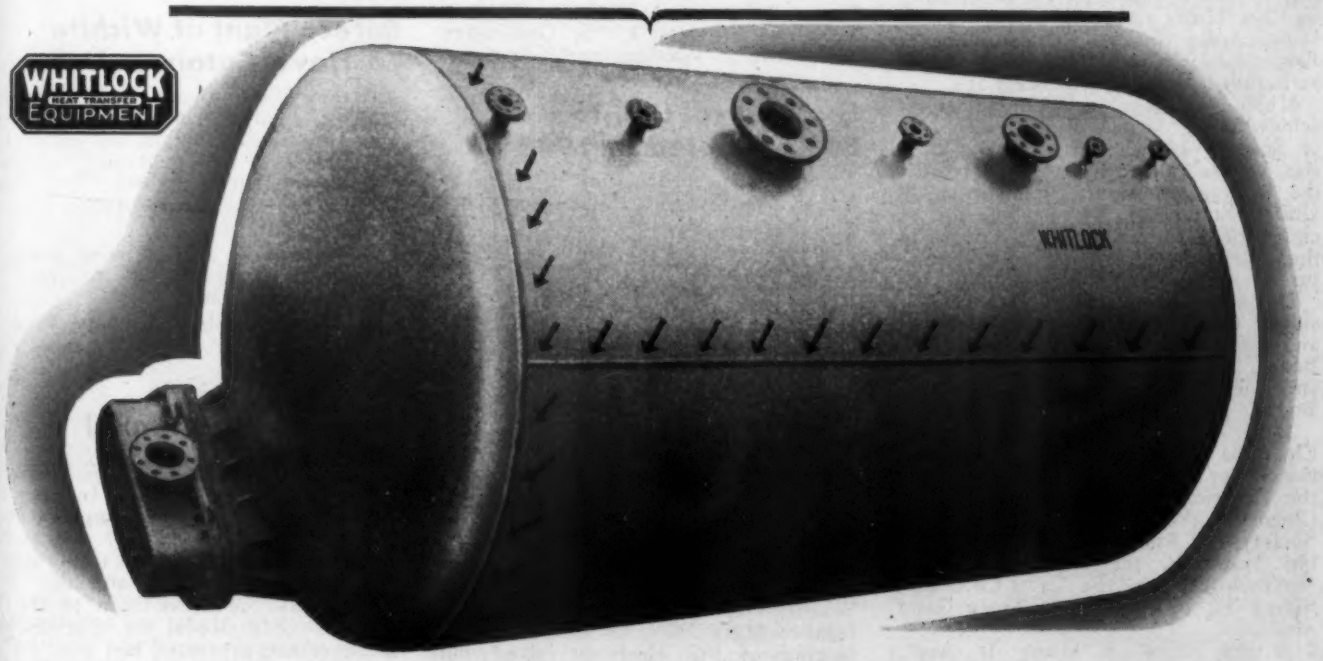

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THE MONTH . . .

CARL S. MINER

from which he graduated in 1903 with a B.S. degree in chemistry. Immediately afterwards he served as a research chemist for Corn Products Refining Company. In 1906, Miner resigned to establish the Miner Laboratories. He continues to direct the activities of the company which he founded more than 40 years ago.

Miner is credited with many scientific achievements. Listed in American Men of Science, his name is denoted by a star which indicates that he is among the leading thousand scientists in the United States. In 1940 he was the recipient of a Modern Pioneer Award from the National Association of Manufacturers.

During the war, Miner was a consultant to the Rubber Survey Committee and a member of the Chemical Referee Board, Office of Production Research and Development, War Production Board.

Miner is a member of the American Chemical Society, the American Association for the Advancement of Science, the American Association of Cereal Chemists, the American Oil Chemists Society, the American Society for Testing Materials, the Institute of Food Technologists, and the Alpha Chi Sigma, Sigma Xi, and Phi Delta Theta fraternities.

A son, Dr. C. S. Miner, Jr., and a daughter, Dr. Barbara M. Parker, are associated with him in the Miner Laboratories.

Translations of German Documents Available

Establishment of a clearing house for coordination of translations of German-language technical documents was announced today by John C. Green, director of the office of technical services, U. S. Department of Commerce.

"There is nation-wide interest in the translation of some of the new technological material discovered in Germany by OTS investigators," Mr. Green stated. "Many business firms have asked us to provide some method of helping translators avoid duplications. The clearing house has been organized to provide this service."

Between 300,000 and 400,000 documents in the German language have been microfilmed by OTS teams, operating from Frankfurt and Karlsruhe. These records were selected by expert evaluators from a much larger mass of material on the basis of their value to American industry. Hundreds of microfilm reels containing the documents are arriving in Washington and are being listed weekly in the OTS bibliography of scientific and industrial reports and offered for sale in microfilm or photostat copies. The reports cover every branch of scientific, technological and industrial knowledge.

"In order that the full advantage of theses documents may be taken by American scientists, manufacturers and businessmen," Mr. Green said, "they must be translated into English. However, OTS cannot finance translations of its German-language technology, nor can it employ translators. It can, however, assist private translating firms and individuals by informing them whether documents they wish to work on are already being translated by others. It can also list all translations of OTS material in the bibliography, together with the price of each translation and the source from which it may be obtained."

Communications concerning translations of German-language technical documents from OTS files should be addressed to the Translation Clearing House, Information Division, Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

Shell Glycol Unit to Be Completed in 1948

Commercial production of hexylene glycol from petroleum will be underway at the Houston plant of Shell Chemical Company, where a unit for that purpose is now under construction.

Among its anticipated uses is that of replacement of other hydrocarbon solvents in flash drying inks and in duplicating fluids, printing pastes and other inks. It is useful also as a treating agent in glues, casein, leather, paper and textile fibers.

General Petroleum Builds West Coast Terminals

General Petroleum Corporation has announced a plan for expansion of its Harbour Island Terminal facilities in Seattle. During the next three years a total of $2,000,000 is to be spent for enlarging of the Harbour Island bulk petroleum plant.

Included in the plans are an over-all increase of 1,450,000 gallons storage capacity for petroleum products. The contract for the first phase of this project has been let to Chicago Bridge and Iron Company for construction of tanks to contain 1,000,000 gallons of aviation gasoline. To be completed during the fall, the new tanks will be equipped with double-deck floating roofs. Lubricating oil tanks are also planned for early construction.

A new warehouse, supply, maintenance, and office buildings at the Harbour Island plant are planned during the near future, at an estimated cost of $1,300,000. Features of this program will include a warehouse for tire and battery storage, increased lubricating oil storage, and new shop and garage space. In addition to the expansion of General Petroleum's bulk plant facilities, a program of water front and land improvement has been jointly undertaken with The Texas Company which occupies the adjoining property. This project includes the dredging of the water front to handle large tankers, the construction of a sea wall facing the water front area recently dredged, and a new pier.

Shell Will Expand English Chemical Plants

Shell Chemical Company Limited of London has announced a program for expansion of facilities for making petroleum chemicals for agriculture and industry. Chief item is a building project at Thornton-le-Moors in Cheshire, England, where work has begun on a chemical plant that will cost several million pounds. Much of the pioneer work in this field is credited to members of the Shell group in the United States.

Besides building the chemical plant at Thornton-le-Moors, Shell Petroleum is expanding its plant at Stanlow on the Manchester Ship Canal, where it makes sodium alkyl higher sulfates (petroleum-derived chemicals used as detergents and wetting agents). Also being enlarged is the plant at Shell Haven, Essex, maker of insecticides, fungicides and other oil products used in agriculture.

Bareco Plant at Wichita To Have Catalytic Unit

Bareco Oil Company, Tulsa, will add a Perco catalytic reforming unit to its Wichita, Kansas, plant as part of a modernization and expansion program to be completed in 1947. The steam plant will be enlarged and additional storage provided.

Consideration also is being given to provision for additional recovery of butane and propane.

Koch Engineering Company, Wichita, has the contract for the work already approved.

API to Make Annual Awards of Merit

The American Petroleum Institute has adopted a policy of a series of annual awards, designed to honor outstanding men for their contributions to the science of petroleum production and use. These awards will be in addition to the Institute's Gold Medal for distinguished achievement, presented last year for the first time, with the late Henry Ford as the recipient.

The certificate of merit will be awarded to those who have contributed outstanding service as an official or member of a division, member of a committee or other organized unit of the organization.

Eight certificates may be presented each year, one each in the divisions of refining, transportation and marketing, two in the non-divisional committees and three for the division of production. These are in proportion to the numbers of persons serving in the various categories.

Five committees are to select candi-

THE MONTH . . .

dates for the awards, transmit their recommendations to the president of the Institute, who will, in turn, pass them along to the Committee on Awards, together with comment. That committee will then make final selections and inform the president of their findings before October 1, each year. Presentations will be made at the annual API meeting.

"Unselfish contributions of outstanding services and assumptions of extraordinary responsibilities by leaders in the petroleum industry and the American Petroleum Institute are rewarded inadequately by a mere feeling of personal satisfaction in accomplishment," said President William R. Boyd, Jr.

"By public acknowledgement and recognition of such contributions, others may show their appreciation and express their thanks to the leaders who advance the work and the best interests of the industry and the Institute."

Teichmann Promoted in Texaco Technical Staff

C. F. TEICHMANN

In addition to technical training at Columbia University Charles F. Teichmann studied law and was a patent attorney with The Texas Company before joining the subsidiary, Texaco Development Corporation, of which he is now a vice president.

Peavy Heads Houdry Engineering Staff

Dr. Claude C. Peavy has been named chief engineer of Houdry Process Corporation, Philadelphia. His promotion came after joining the organization a year ago as chief of the process design division.

Previously he had gained wide experience in petroleum refinery engineering.

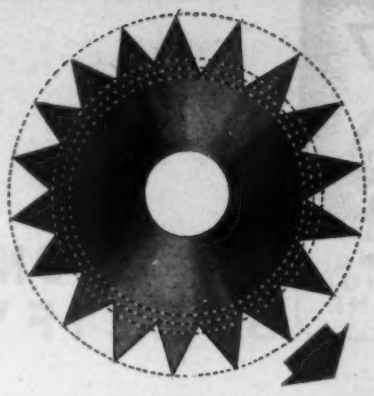

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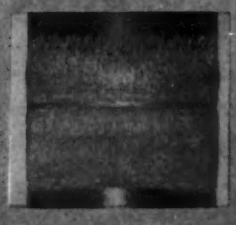
Illustration below shows the same tube when Airetool's new form cutters were used and held for the same length of time. No tracks . . . no tube damage.



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THE MONTH...

He was on the staff of E. B. Badger & Sons Company for nine years, during which he worked on the design of the first Houdry fixed bed catalytic cracking unit. He also had considerable foreign experience as a member of the Badger staff.

His next connection was with the refinery engineering division of Socony-Vacuum Oil Company, New York, where he was chief process engineer. He was with Socony-Vacuum five years before joining the Houdry engineering department.

DR. CLAUDE C. PEAVY

Other promotions in the Houdry staff bring Harmon J. Monnik to the position of chief of the mechanical engineering department and William C. Dickerman will be in charge of process design.

Development engineering will continue at the Houdry laboratories, Marcus Hook, Pennsylvania, under the direction of Raymond C. Lassiat.

The Texas Company, Establishes Fellowship

The Texas Company has established a fellowship at Northwestern University for the study of fundamentals in thiophene chemistry. Thiophene is an aromatic, similar to benzene, which has the properties of that product as well as the reactivity of phenols.

Professor R. K. Summerbell, chairman of the chemistry department at Northwestern, said that he hoped the fellowship would further the studies of this basic material and the chemistry of the organic reactions in which thiophene or its derivatives play a part.

Wallace Promoted At Freedom Plant

G. W. Wallace has been promoted to superintendent of the Freedom, Pennsylvania refining plant of Valvoline-Freedom Oil Company. For the past 10 years he has been chief chemist in charge of development and refinery laboratories.

THE MONTH • • •

He succeeds L. H. Major, who has been promoted to manager of the pipe line division of the company.

G. W. WALLACE

Wallace joined the company shortly after graduation from Geneva College and his whole business career has been within the field of processing lubricants. For a number of years he conducted an extension course at Pennsylvania State College on petroleum refining. He is a member of the American Chemical Society, Society of Automotive Engineers and the American Society of Lubricating Engineers.

Compact Commission To Meet in Great Falls

The summer quarterly meeting of the Interstate Oil Compact Commission will be held in Great Falls, Montana, August 11, 12 and 13, Chairman Hiram M. Dow has announced. A program to encourage more effective oil and gas conservation in the western states is being planned, details of which will be announced following the June meeting of the commission's executive committee.

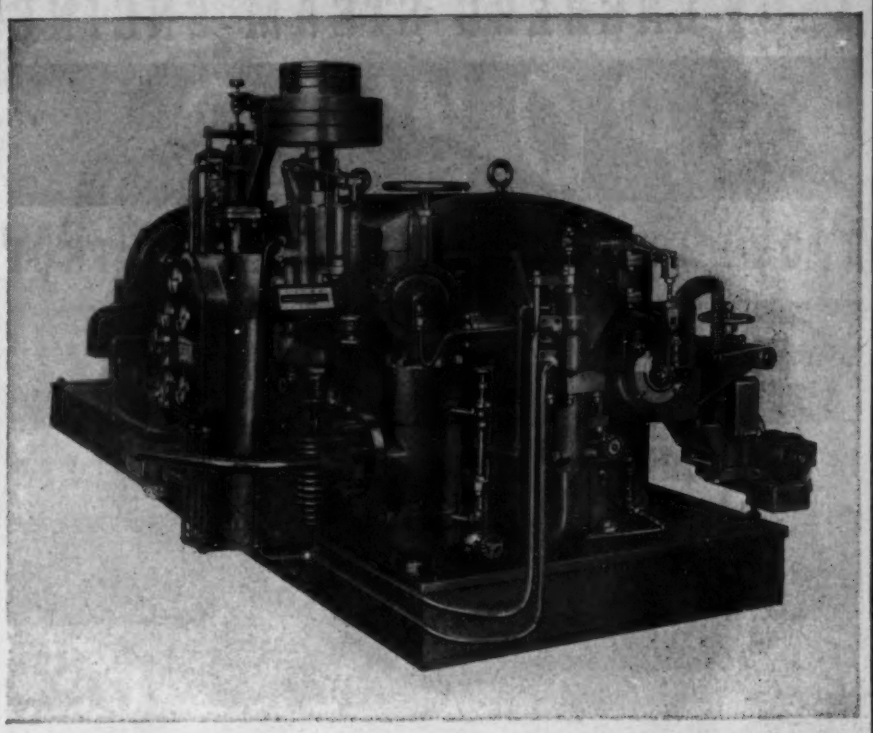
Montana became a member of the commission in 1945, and this is the first meeting of the compact to be held in the state. Governor Sam C. Ford has designated members of the Montana Oil Conservation Board to make plans.

Socony-Vacuum Foreign Trade Appointments

Appointment of Francis E. Powell, Jr., as chairman of the foreign trade committee of Socony-Vacuum Oil Company, Inc., and F. H. Henry as vice chairman has been announced by Walter L. Faust, vice president and director in charge of foreign trade.

Arthur G. Reed and O. J. Bellis have been made members of the foreign trade committee.

L. A. Blumenthal and M. J. A. Bertin



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were appointed to the newly-created positions of assistant to the general manager of foreign trade. C. V. Barry will become European representative of the foreign trade committee's planning staff with headquarters in London, Charles F. Darlington becomes American representative and C. T. Crawford will be manager of the supply operations.

White Eagle Lets Contract

Catalytic Construction Company, Philadelphia, has been given contract for modernization and expansion of the refining plant of the White Eagle Division Socony-Vacuum Oil Company, Augusta, Kansas. Included is the construction of a small-scale TCC cracking unit, 4000 barrels daily capacity. A feed preparation unit, gas concentration system, polymerization unit and other improvements will be other major phases of the work, which is slated to start in August.

Swensrud Named Executive Officer of Gulf Company

Sidney A. Swensrud has been elected executive vice president and member of the board of directors of Gulf Oil Corporation, and will assume his duties at

S. A. SWENSRUD

Pittsburgh about the middle of June. At present he is executive vice president of Standard Oil Company of Ohio at Cleveland.

Swensrud has been active in the American Petroleum Institute, the American Institute of Mining and Metallurgical Engineers and numerous industry committees and associations, and is recognized as a leading authority of the industry in economics, especially in the marketing and distribution phases.

Born August 1, 1900, at Northwood Iowa, Swensrud was graduated at the

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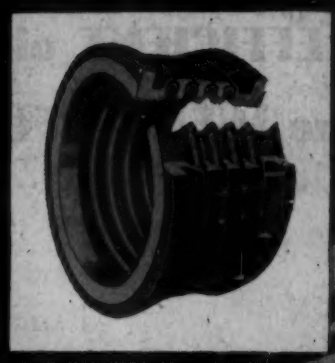

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THE MONTH . . .

University of Minnesota, receiving the B. S. degree with honors in 1923. He then joined Washburn-Crosby Company (now General Mills). In 1925 he went to the Harvard Graduate School of Business and graduated with distinction in 1927 with master's degree in business administration. In August, 1928, he became assistant to the president of the Standard Oil Company of Ohio, and was made vice president in charge of production, supply, and transportation in August, 1939, director in April, 1940, and executive vice president in 1946.

Gas Technology Short Course Is Held at Texas A. & I.

Utilization of natural gas and problems involved in its production and transportation were on the program of the second annual short course in gas technology at Texas College of Arts and Industries, May 27 to 30. The course is sponsored by the Southern Gas Association and is directed by Dr. Frank H. Dotterweich, head of engineering department of the college.

In general assemblies the group heard papers presented by J. A. Crichton, of DeGolyer and MacNaughton, of Dallas; Dr. Drew Mayfield, Celanese Corporation, Bishop, Texas; Capt. E. S. Pettyjohn, director of the Institute of Gas Technology, Chicago; and R. M. Hutchison, research director, Houston Natural Gas Corporation, Houston.

Crichton saw a bright future for the United States regarding its gas reserves and said the conservative figure of 151 trillion cubic feet representing the amount of recoverable gas reserves, could more easily be 200 trillion cubic feet as far as national planning is concerned.

Dr. Drew Mayfield discussed the chemicals being made at the Celanese plant in Bishop, and said his company was the largest consumer of acetic anhydride and acetic acid in the country. Tetrahydro furane, a solvent and intermediate, is scheduled for quantity production in the near future, he said.

Research activities accomplished and underway at the Institute of Gas Technology were described by Capt. E. S. Pettyjohn. He also told the group of a special gas research committee at the institute.

Frank C. Smith, president of the College's board of director's and president of the Houston Natural Gas Corporation; President E. N. Jones of the College; Robert R. Suttle, managing director of the Southern Gas Association; Frank S. Kelly, Jr., Arkansas Louisiana Gas Company, advisory committee chairman, also were speakers on the general assembly programs.

Other papers presented during the course included "Latest Pressure Welding Technique," by A. L. Forbes, Jr., Associated Contractors and Engineers, Houston; "Methods of Estimating Natural Gas Reserves," J. F. Dougherty and H. J. Gruy, DeGolyer and MacNaughton; "Principles of Automatic Controls Applied to Natural Gas Operations," L. W. Parten, Foxboro Company, Houston; "Improved Methods of Pipe Line

Design," by W. C. McGee, Jr., Tennessee Gas and Transmission Company, Houston, and R. M. Hutchison, Houston Natural Gas Corporation; "Corrosion in Condensate Wells," by R. C. Buchan, Humble Oil & Refining Company.

The delegates were taken on field trips to the Rio Grande Valley visiting the La Gloria Cycling plant at Falfurrias, Evergreen Farms cereal dehydration plant at Raymondville, Valley Vitamins, Inc., at McAllen, Universal Colloids Company, McAllen.

Opponents Score Changes In Natural Gas Statute

Opponents to the proposed revision of the natural gas act, under which the Federal Power Commission functions, had their day before the House Interstate and Foreign Commerce Committee, which completed its hearings on the Rizley bill the last week in May.

Starting with Jerome Joffee, special utilities and legislative counsel for Kansas City, Mo., also representing the National Institute of Municipal Law Officers, and winding up with Chairman Nelson Lee Smith of the Federal Power Commission, they outlined their reasons for opposing revision of the Natural Gas Act.

Before starting on the final lap of the Rizley hearings, the committee heard testimony on the Schwabe bill to give natural gas companies the right of eminent domain to secure right-of-ways when they could not come to an agreement with landowners.

At hearings before the Moore subcommittee of the Senate Interstate Commerce Committee last month, FPC Chairman Smith declared the commission had no objection to the legislation, which David T. Searls, attorney for Texas Eastern Transmission Corporation, told the House group was urgently needed to insure that his company would have right-of-ways for use of the Big Inch pipe lines for gas, before completing its purchase from the government.

Searls had only one suggestion with respect to the wording of the bill, to provide that all suits could be brought in the federal courts instead of only those involving more than $3000, pointing out that the eminent domain laws of some of the states are inadequate, in some instances conferring the right only upon corporations incorporated under the state law and in others granting it only to pipe lines which serve the people of the state. In such cases, difficulty might be encountered in getting right-of-ways through the state courts.

The bill was also supported by J. J. Hedrick, general counsel for the Natural Gas Pipeline Company of America and Texoma Natural Gas Company, and F. L. Daily, attorney for the Chicago District Pipe Line Company.

Hedrick recommended that the bill be amended to give the right to companies making additions to their systems without FPC certificates, as contemplated in regulations to be adopted by the commission.

The right of eminent domain is needed to enable pipe line companies to cope with the railroads, Hedrick said, explaining that even after the FPC grants a certificate the railroads frequently delay permission for months.

Daily told the committee that his company has frequently been held up by landowners.

Opposition to the measure was offered by John M. Crimmins of The

Standard of Indiana Technical Conference

Clockwise around the table: A. W. Neeley, director of research, Utah Oil Refining Company; M. G. Paulus, vice president in charge of refining, Standard Oil Company (Indiana); George Roberts, Jr., manager of research, Stanolind Oil & Gas Company; D. J. Smith, president, Pan American Petroleum & Transport Company; J. K. Roberts, general manager of research, Standard Oil Company (Indiana); Robert E. Wilson, chairman of the board, Standard Oil Company (Indiana); Bradley Dewey, president, Dewey & Almy Chemical Company; Bruce K. Brown, vice president, Standard Oil Company (Indiana); L. W. Moore, general manager of research, Pan American Petroleum & Transport Company.

The fifth annual conference of executives, technologists and operating personnel of Standard Oil Company (Indiana) and its affiliated companies was held May 5-9. In addition to the parent companies, men from these subsidiaries attended: Pan American Petroleum & Transport Company, Stanolind Oil & Gas Company and Utah Oil Refining Company.

While the principal attendance was from the various research departments, there were also representatives of the manufacturing, engineering, production, sales, chemical products, and development and patent departments. Approximately 150 people attended. Eighty-one papers were presented under eight general headings: motor fuels, the Synthol process, engineering and process design, technical service, process development, general research, chemicals, and miscellaneous problems.

At a dinner Bradley Dewey, president of Dewey and Almy Chemical Company and rubber administrator during the war, spoke on "Is It Too Late for Leaders in Petroleum to Lead in Chemicals?"

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

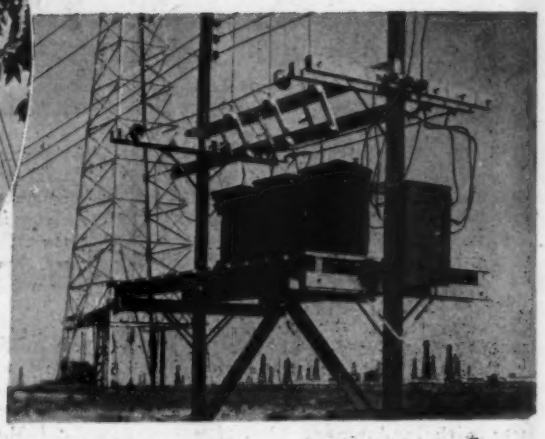
(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1946:									
January 26	4,626	4,553	221,544	13,622	101,737	5,720	29,498	8,411	39,722
March 2	4,726	4,779	229,430	13,871	104,462	5,888	25,148	8,634	38,441
March 30	4,425	4,684	224,994	13,896	104,715	5,337	28,240	8,738	37,746
April 27	4,672	4,685	224,443	14,228	99,631	5,568	30,466	9,204	39,404
May 25	4,759	4,857	222,214	14,322	95,769	5,463	32,973	8,908	43,368
June 29	4,957	4,854	223,883	14,500	92,333	5,325	37,762	8,828	46,447
July 27	4,926	4,896	223,756	14,535	88,626	5,817	44,316	8,217	49,517
August 24	4,836	4,866	225,672	14,639	86,251	5,649	51,405	8,126	52,061
September 28	4,778	4,829	221,903	14,538	85,854	5,450	57,903	8,158	56,914
October 26	4,730	4,758	221,184	14,863	86,423	5,710	65,499	7,728	60,872
November 30	4,795	4,707	225,119	15,145	88,371	5,228	66,062	7,672	58,647
December 28	4,713	4,968	226,111	15,604	93,126	5,931	58,941	8,181	53,427
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,357	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	8,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,86	5,435	32,286	8,186	42,668
May 24	[1]5,025	4,970	.....	14,927	97,827	5,518	35,212	8,292	44,499

[1] All time peak.

IT REQUIRES . . . .

Capital Investment



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Koppers Company, Inc., who also opposed the Rizley bill.

Favorable action on the Rizley bill was urged by two Texas congressmen, John E. Lyle of Corpus Christi and Eugene Worley of Shamrock, who briefly discussed the uncertainty of the oil industry and resultant waste of gas because of fears of the FPC and contended that the legislation will not take away any powers the commission rightfully has but will take away the threat of powers which it may seek to assume.

The final witness before the committee was Chairman Nelson Lee Smith of the FPC, who read a statement identical with that he submitted exactly one month earlier before the Senate Interstate Commerce Subcommittee. (THE OIL WEEKLY, May 5.)

Smith again urged that action on revision of the act be deferred until the commission has completed the report on its natural gas investigation.

Magnolia Dedicates West Ranch Gasoline Plant

The new gasoline plant for the West Ranch field, near Vanderbilt, Texas, was put on steam June 3 following ceremonies that included extinguishing flares in the field, a program and a barbecue, attended by more than 500 persons. The plant is a belated pre-war project, as first plans were to build it in 1941. Requirements for materials in the military effort delayed the project, which was revived in September, 1945, and work finally put under way in August, 1946. Shortage of materials has handicapped the contracting firm, Hudson Engineering Corporation, Houston, which managed to maintain schedules despite the drawback.

The plant has capacity for 25,000,000 cubic feet of gas daily, from which recovery of 40,000 gallons of liquid is anticipated. Dry gas not used in the field will be piped to the Magnolia refining plant at Beaumont for fuel.

Colonel E. O. Thompson, chairman of the Texas Railroad Commission, turned the master gate, which extinguished field flares. Olin W. Culberson, and W. Z. Murray, commission members, were present for the ceremony.

New Gasoline Plant For Agua Dulce Field

Plomo Company, Corpus Christi, will build a gasoline extraction plant for the Agua Dulce and Brayton field, Nueces County, Texas, following approval by the Texas Railroad Commission. The project calls for pressure maintenance by return of residue gas to the producing formations of each field.

NPA Meeting Dates Set

National Petroleum Association will hold two meetings in 1948: the annual meeting in Atlantic City, September 17, 18 and 19 with the Traymore hotel as headquarters, and the spring meeting April 21, 22 and 23 in Cleveland, Ohio, with headquarters in the Cleveland hotel.

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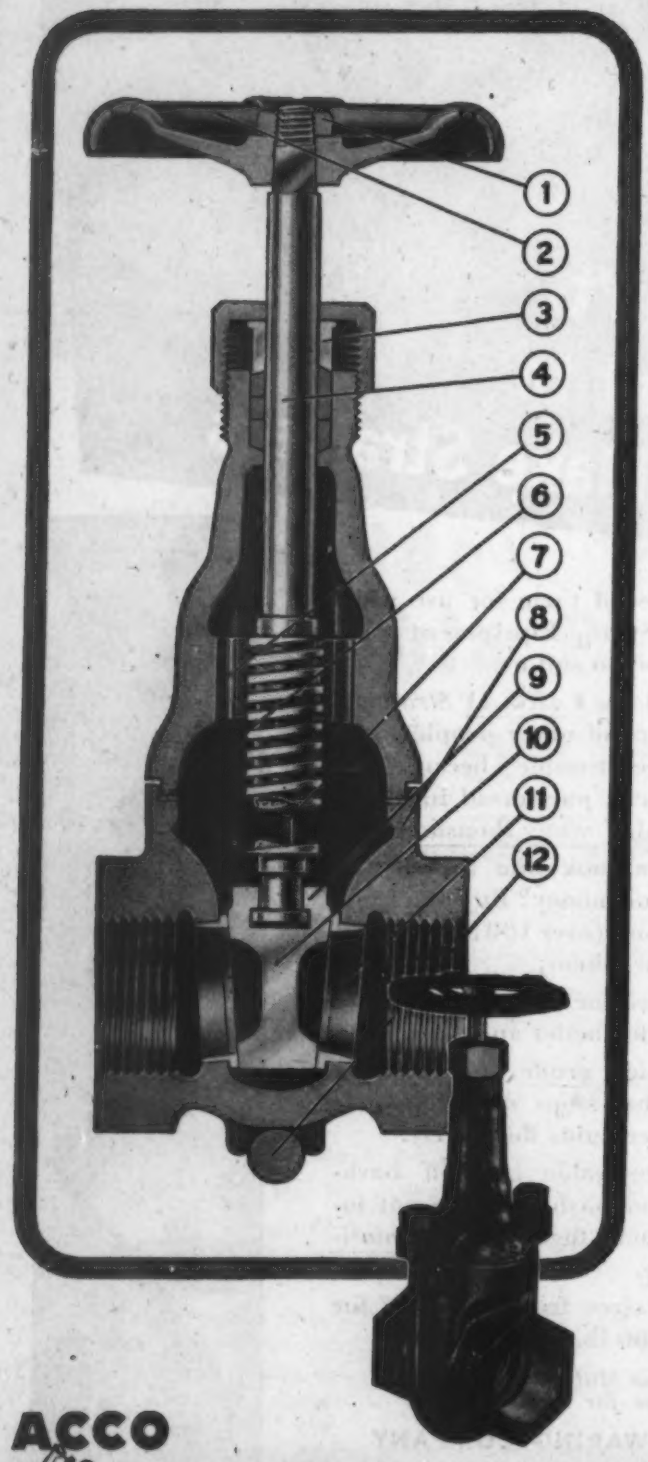

Quick cleanout a *plus* feature of this good, tight, sturdy gate valve. Made of close-grained Hi-Test Gray Iron—50% stronger than ordinary iron.

1. Heavy wheel nut
2. Kool-grip malleable iron ventilated hand-wheel
3. Deep stuffing box with follower. Can be packed under pressure
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5. Full, adequate bonnet drain prevents possible trouble from freezing in outside installations
6. Male and female bonnet joint with asbestos gasket
7. Fully-machined wedge guides in body
8. Body and bonnet of close-grained Hi-Test Gray Iron—50% stronger than ordinary iron
9. Horseshoe type slip-on connection
10. Heavy cast I-beam wedge—reversible and renewable. Wedge rises above flow when open
11. Rolled-in seat ring (in bronze-mounted type)
12. Full U-bolt in closed bolt holes. Held in place by 3 sets of lugs on body

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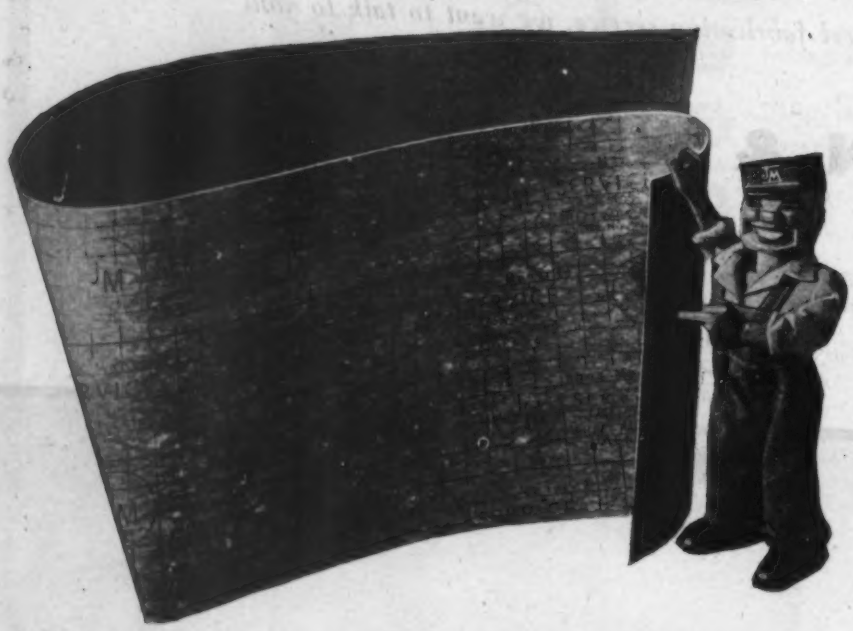
Letter Symbols for Chemical Engineering Standard OK'd

"Letter Symbols for Chemical Engineering," ASA Z10.12—1946, has been prepared by groups active for the last several years, and designated as an American Standard by the American Standards Association as of September, 1946.

The new standard is the work of Subcommittee No. 12 on Letter Symbols for Chemical Engineering, appointed in July, 1943, by H. M. Turner, Chairman of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering, Z10, of the American Standards Association. Subcommittee No. 12 included: J. H. Perry, Chairman, technical investigator, development department; and T. H. Chilton, manager of the development engineering division, E. I. du Pont de Nemours & Company; W. H. McAdams, professor, department of chemical engineering, Massachusetts Institute of Technology; W. L. McCabe, head department of chemical engineering, Carnegie Institute of Technology; F. J. VanAntwerpen, Editor, Transactions, American Institute of Chemical Engineers, and K. M. Watson, department of chemical engineering, University of Wisconsin.

The work of this subcommittee, which was based on earlier work of an A. I. Ch. E. committee, was completed in November, 1944, approved by Sectional Committee Z10, by the sponsor bodies of the American Standards Association, and finally by the American Standards Association.

It's called SERVICE SHEET



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Turner to Supervise Coal Research Program

Howard S. Turner has been named assistant director of the research and development department of Pittsburgh Consolidated Coal Company, which recently announced a program of conversion of coal into liquid products by adaptation of Fischer-Tropsch methods. Turner has been with E. I. du Pont de Nemours & Company, Wilmington, for the past 11 years in its research and development activity.

He is a graduate of Swarthmore College, class of 1933, and completed his work for a doctorate at Massachusetts Institute of Technology in 1936.

HOWARD S. TURNER

Cutting-Oil Additive

Socony-Vacuum Oil Company has announced development of a new cutting-oil additive which replaces sulfurized fatty materials in fluids for machining carbon and alloy steels, including stainless steel. The new product is being used in the company's "Sultran" line of cutting oils.

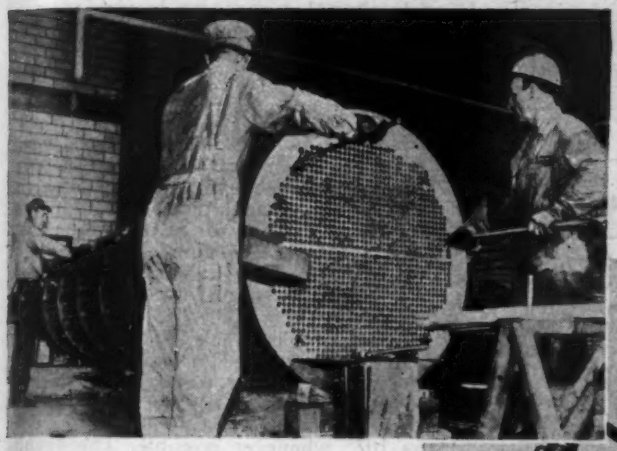
Tests showed, it was said, that the additive is highly effective in increasing the oiliness of the basic cutting fluid. Cutting oil with this additive is described as having light color, transparency, no odor, and high cutting efficiency. Other advantages are elimination of gumming and possibility of rancidity, as well as a safeguard against dermatitis which sometimes results from contact with cutting fluids containing fatty oils.

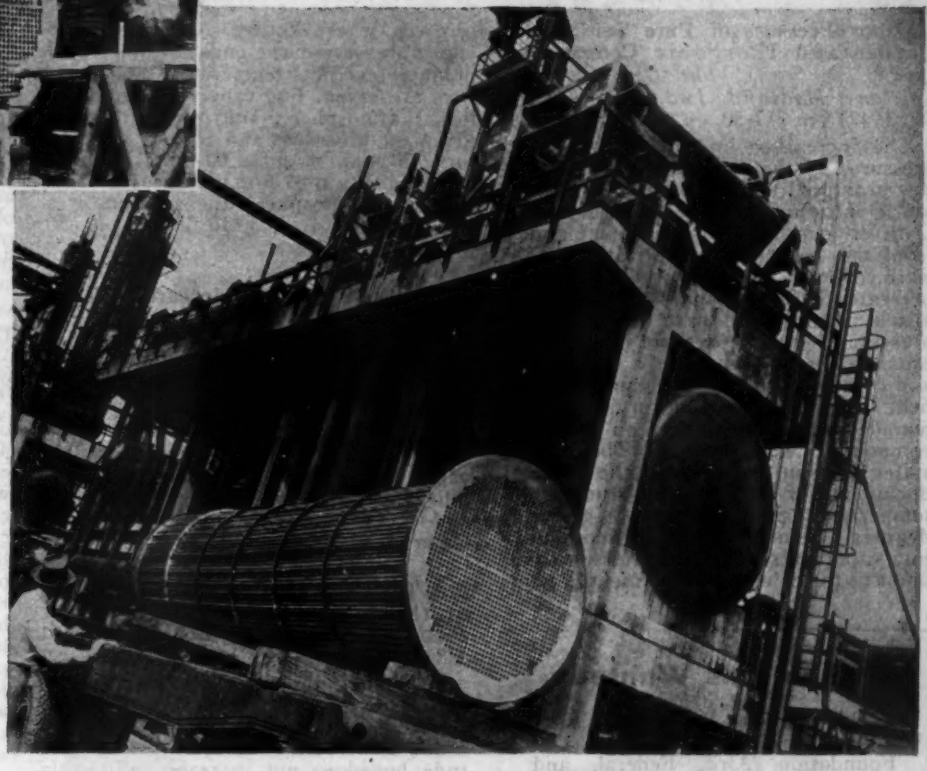
Carnell Joins Leonard

Dr. Paul H. Carnell has joined the staff of Leonard Refineries, Inc., Alma, Michigan, where he is in charge of its research and development activity. Until recently he was in the research department of Phillips Petroleum Company, Bartlesville.

Light Hydrocarbon from Fractionating Towers

handled by ANACONDA ARSENICAL ADMIRALTY TUBES...





(Above) Inserting Anaconda Arsenical Admiralty 439 Tubes in tube bundle at Houston, Texas, butadiene plant of Sinclair Rubber, Inc. Photograph at right shows tube bundle ready for installation in one of the shells on top of superstructure.

THE CONDENSERS shown in the photographs above are located at the butadiene plant of Sinclair Rubber, Inc., Houston, Texas. They were built to handle light hydrocarbon from the fractionating towers.

In order to provide the required heat transfer and economical service under the corrosive conditions encountered, the tubes being installed are Anaconda Arsenical Admiralty 439.

This Anaconda Alloy has been manufactured on a commercial basis since 1934. It is but one of 11 standard and several special condenser tube alloys currently produced by The American Brass Company.

This list provides tubes to meet a wide range of heat transfer requirements. The broad metallurgical knowledge and practical experience of our Technical Department is available in helping you make the right selection. 48174

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Subsidiary of Anaconda Copper Mining Company

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SCIENCE AND TECHNOLOGY ABSTRACTS

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by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Michigan
under supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Vapor Pressure of Pure Substances. Organic and Inorganic Compounds. DANIEL R. STULL, *The Dow Chemical Company, Midland. Ind. Eng. Chem.*, **39** (1947) pp. 517-50.

The increasing importance of vapor pressures in the operations of technology prompted the author to assemble as much information as could be found. Data on over 1200 organic compounds from the literature and private sources were collected, critically studied, and are presented in accompanying tables in the article. The second part of the article presents the vapor pressure data for approximately 300 inorganic compounds and completes the author's survey of the field. 494 references on organic compounds and 499 references on inorganic compounds were studied. The author states that in most cases the original documents or articles were studied. All temperatures in the table are given as degrees C. Since there is a discontinuity in a vapor pressure curve at the melting point of the compound, the melting point is given where known. Also, since the vapor pressure curve ends at the critical point, the critical temperature and pressure are given. For vapor pressures below 1 atmosphere, temperatures are given for pressures at 1 mm., 5 mm., 10 mm., 20 mm., 40 mm., 60 mm., 100, 200, 400, and 760 mm. For pressures greater than one atmosphere the temperatures are given for 1, 2, 5, 10, 20, 30, 40, 50 and 60 atmospheres.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal, and Dearborn Streets, Chicago 16, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

1,4-Pentadiene
2-Methoxy-4-ethylphenol
2-Methoxy-4-vinylphenol
2,6-Dimethoxy-4-methylphenol
2,6-Dimethoxy-4-propylphenol
Carbamyl bromide
Vinylchloroacetate
Mesoxalic acid
2-Ethyl-1,3-hexanediol
1,3-Dihydroxy-2,4-dichlorobutane
1,4-Dichloro-2-butene
1,4-Dichloro-2,3-dihydroxybutane
1,2-Epoxy-3,4-epoxybutane
Diphenylphosphoryl chloride
4-tert. Butyl-2-phenylphenol
Orcinol
5-Amino-2-phenylbenzoxazole
6-Amino-2-phenylbenzothiazole
Dehydrothiotoluidine
2,5-Dinitroso-p-cymene

Phase Relations of Hydrocarbon-Water Systems. JOHN J. MCKETTA, JR., AND DONALD L. KATZ. *Am. Inst. Mining Met. Engrs.*, **10**, (1947) 2 No. 1, Tech. Pub. No. 2123.

The system methane-n-butane-water was studied and data considered along with published data to present the water-vapor content of natural gases, the solubility of water in hydrocarbon liquids, and the solubility of natural gases in water.

A Theory of the Critical Temperatures of the Normal Paraffins. J. CORNER. *Proc. Cambridge Phil. Soc.*, **42** (1946) 328-37.

A simple model of an independent curled-up molecule is considered theoretically. The critical temperature is found to be of the right order of magnitude but does not increase sufficiently rapid with the size of the molecule. The Onnes constant and the critical density show discrepancies that would be expected from the theoretical equation of state, and the former has an incorrect dependence on mol. wt. In the critical region, therefore, the paraffin hydrocarbons cannot be regarded as an assembly of independent molecules curled up in the way expected at high temperatures and low densities. Each molecule cannot be considered as uniformly distributed in a certain spherical volume no matter what its surroundings. The extent of the curling-up is greatly influenced by the intermolecular fields. The simplest picture of curled-up molecules is in several respects in disagreement with experimental information in the critical region.

A Theoretical Evaluation of Normal Frequencies of Vibration of the Isomeric Octanes. CHARLES O. AHONEN. *J. Chem. Phys.* **14** (1946) 625-36.

Some of the normal frequencies of vibration of the isomeric octanes were evaluated theoretically. The report gives the skeletal frequencies for those of the 18 isomeric octanes that led to representations of having 7 or fewer frequencies. The forces are assumed to be valence forces. The force constants used were 4.12×10^5 dynes/cm. for the C-C bond stretching, and 0.37×10^5 dynes/cm. for the bending between 2 C-C bonds, the values being based on computations by the author for propane, using the experimental data of Baker and Wu. The angle between 2 C-C bonds was taken as 107° whenever possible. The results of the study are summarized by means of charts, showing the location of the bonds calculated.

Cuprous Chloride Derivatives of C_5 Diolefins. A. L. WARD AND E. C. MAKIN, JR., *Jour. Am. Chem. Soc.*, **69** (1947) pp. 657-9.

The equilibrium dissociation pressures over a range of temperature for the compounds formed between piperylene and cuprous chloride were determined as well as the dissociation pressures for the compounds of isoprene and cuprous chloride, which had been previously determined by others. The stability of the piperylene-cuprous chloride compound is approximately the same as that of the butadiene-cuprous chloride compound, but the isoprene-cuprous chloride compound is considerably less stable. The formulas of all the complex compounds are found to be 1 molecule of hydrocarbon combined with 2 molecules of cuprous chloride.

Production of Cumene by Vapor- and Liquid-Phase Alkylation Processes. S. H. MCALLISTER, JOHN ANDERSON, AND E. F. BULLARD. *Chem. Eng. Progress*, **43** (1947) pp. 189-96.

Cumene became of great importance during the war because its addition to paraffinic fuels allowed a substantial improvement in performance, particularly in military aircraft engines at the time of take-off or under combat conditions where maximum power was required. Also the addition of these aromatics to substantially paraffinic fuels permits a decrease in the amount of synthetic paraffinic ingredient required to reach a given octane level, and thus, by substituting the aromatic for an even greater quantity of the synthetic paraffinic components, a marked increase in the overall production of a given grade of fuel was possible. 1 vol. of cumene could be substituted for 2½ to 3 vol. of alkylate and it was estimated that the manufacture of cumene was responsible for 23 percent of the increase in volume of avi-

ation gasoline in the critical period 1942 and '43. Although the basic reactions for the alkylation of benzene with propylene to give cumene were known, there was no significant commercial production prior to May 1942. The Shell Companies were aware of the excellent properties of cumene as a blending agent and had made process studies for its manufacture, and were thus able to undertake commercial production rapidly. The authors describe the two catalytic processes that were developed. The most widely adopted was a vapor-phase alkylation process employing a phosphoric acid-kieselgur catalyst. This was attractive because existing facilities could be readily adapted. One of the largest cumene plants in the world, however, employed sulfuric acid as catalyst for the liquid-phase alkylation process. The paper summarizes the process data obtained in the experimental work and gives some typical data from full scale operation. The production of cumene rose from about 400 barrels per day in May, 1942, to more than 15,000 barrels per day by December, 1944.

Equilibrium Constants of Some Reactions Involved in the Production of 1, 3-Butadiene. FERDINAND G. BRICKWEDDE, MORRIS MOSKOW, AND JOHN G. ASTON. *J. Research Natl. Bur. Standards*, **37** (1946) 263-79.

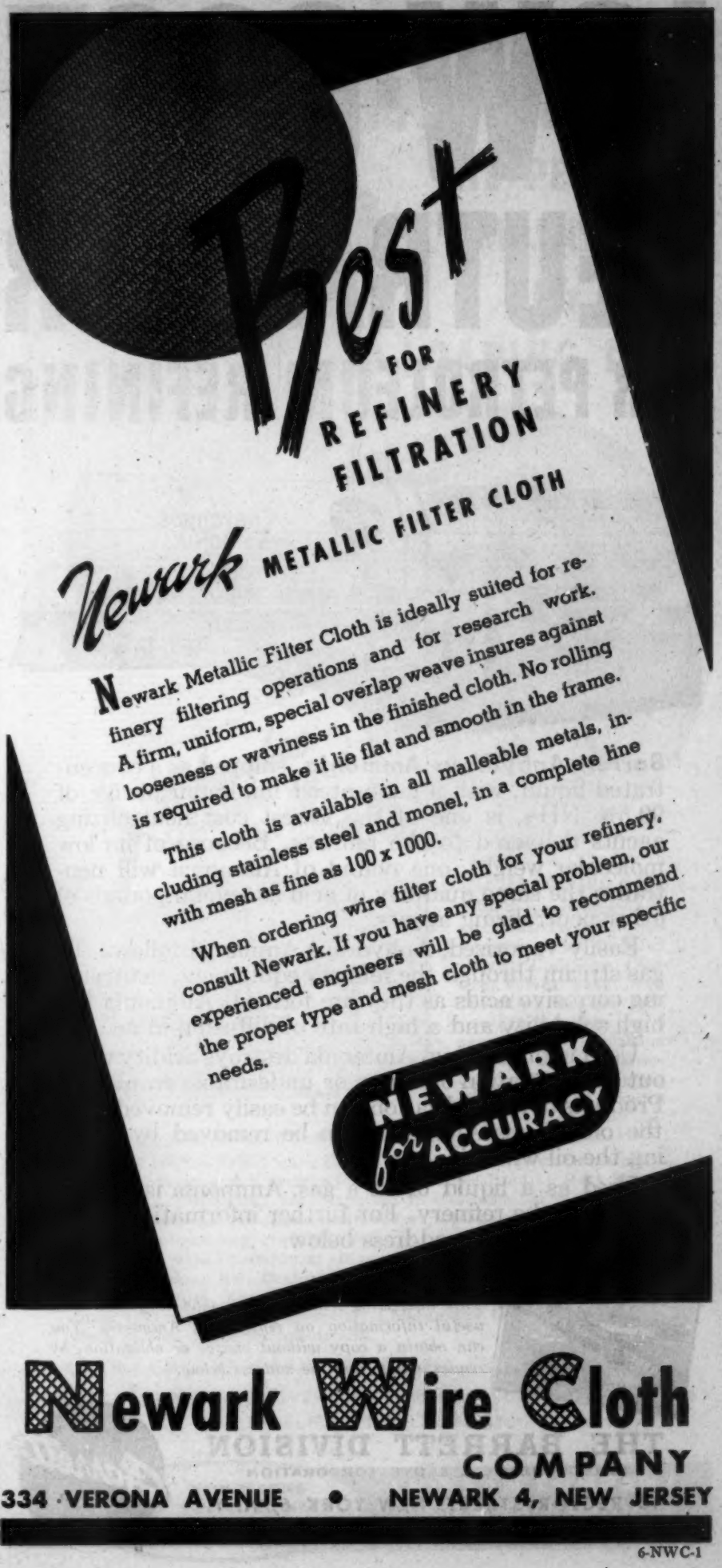
Thermodynamic functions including free energy, enthalpy, entropy, and sp. heat, are given for butadiene, cyclohexane, methane, ethylene, ethyl alcohol, and water and for the elements carbon, hydrogen and oxygen. Equilibrium constants for reactions of interest in connection with the production of 1,3-butadiene for synthetic rubber are calculated and tabulated. The cracking of hydrocarbons is considered and the importance of reaction rates in determining the amounts of reaction products is noted.

Cracking of Paraffin Hydrocarbons in the Presence of Aluminum Chloride. V. I. KOMAREWSKY AND S. C. ULICK. *Jour. Am. Chem. Soc.*, **69** (1947) pp. 492-5.

When the paraffin hydrocarbons, (n-hexane, n-heptane and n-octane,) are treated with aluminum chloride-hydrogen chloride at a temperature near their boiling point or slightly above, cracking occurs with formation of lower boiling isoparaffins. The principal product is isobutane. The cracking reaction involves the dealkylation of the paraffin and the polymerization-depolymerization of the cracked fragments to produce isoparaffins. The amount of dealkylation reaction is a direct function of catalyst concentration. No destructive alkylation to form hydrocarbons boiling at a higher temperature than the charge occurs under these conditions. The results of the experimental work are presented in detail in tabular and graphical form.

Manufacture of Sulfolanes and Use as Selective Solvents. H. G. STAATERMAN, R. C. MORRIS, R. M. STAGER, AND G. I. PIEROTTI. *Chem. Eng. Progress*, **43** (1947) pp. 148-51.

Sulfolanes are solvents developed during the war years for use in separation processes. They are hydrogenated forms of diolefin-derived sulfones; the name "sulfolane" was coined for convenient use in designating the parent ring structure of the compounds in view of the cumbersome nature of ordinary nomenclature. Procedure in making sulfolanes from acetone is described, and flow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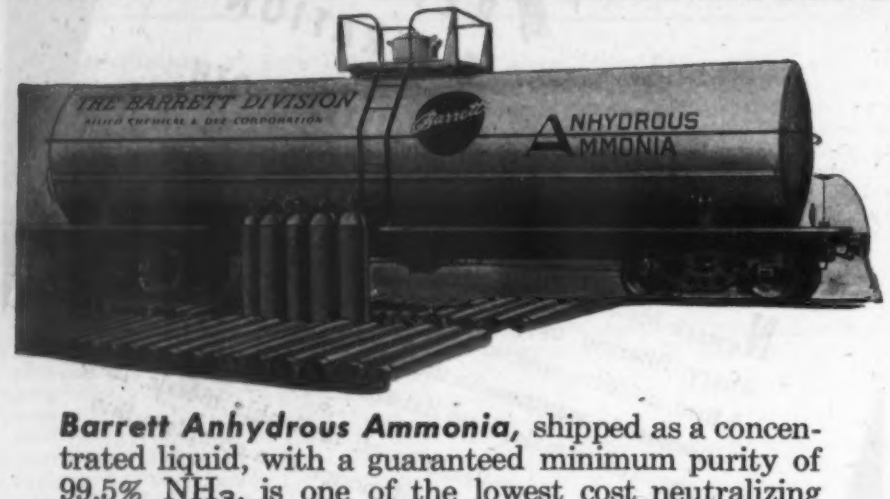

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sheets are presented for the plant units involved. Sulfolane can also be made from butadiene and sulfur dioxide. Sulfolanes are useful as selective solvents for both liquid-vapor and liquid-liquid extraction processes for separating solutions of components having different degrees of saturation or polarity. They can be used to separate aromatics from paraffins, naphthenes, and olefins, to desulfurize petroleum fractions, or to refine vegetable oils. Data are presented concerning the selectivity of sulfolanes with a number of other compounds. Data are given for liquid-liquid extraction for separating toluene from a petroleum fraction and limited data for the treatment of soybean oil by extraction.

Production of Waxes from California Crudes. R. A. David and P. M. Huemmer. *Chem. Eng. Progress,* **43** (1947) pp. 174-6.

The authors describe the manufacture of refined waxes from the crude wax produced by solvent extraction and solvent dewaxing of California lubricating oil distillates. The products were two grades of wax, 143-150 AMP and 160-65 AMP. Three steps are involved in the process. 1. Distillation of the crude wax, 2. Deoiling the crude wax distillates, and 3. Decolorizing of deoiled wax fractions. The crude wax is distilled to make cuts of proper boiling range to yield wax of desired melting-point and to remove asphaltic fractions that were previously added to assist in dewaxing. The distillation is conducted under vacuum. Deoiling is effected by chilling the crude wax distillate, crystallizing the desired wax fractions and then adding methyl-ethyl ketone as a solvent for the filtrate oil and low melting-point waxes. The slurry is then filtered on a rotary filter, repulped with fresh solvent and filtered in a second rotary filter to produce wax containing less than 0.5 percent oil. Decolorization of the deoiled wax is accomplished by contact clay treatment with 3 to 10 percent of activated clay at 300 to 325° F. The contact time is 1 to 2 hours, depending on the feed rate. Spent clay is removed from the decolorized wax in a rotary-type precoat filter. It is necessary to exclude oxygen throughout the clay-treating system to prevent color degradation of the decolorized wax. Following filtration the decolorized wax is steam-stripped under vacuum to remove any traces of odor or taste. A flow sheet showing the complete process is included in the article.

Selection of Centrifuges for Chemical Processing. Julian C. Smith. *Ind. and Eng. Chem.,* **39** (1947) pp. 474-9.

The various types of batch, batch-automatic, and continuous centrifuges are described briefly. The semi-empirical test methods used in selecting centrifuges for process work are considered and the procedure for estimating the capacity of a batch centrifuge from test data is given in detail. Not all separation problems can be solved by centrifuges. The continuous centrifuges are not applicable to the dewatering of fine light solids, particularly where good washing is desired. Certain solids pack tightly under centrifugal force, which completely prevents the flow of liquid through them. However, many materials can be handled better centrifugally than by any other method. Gelatinous materials that quickly plug a filter can be removed from a liquid by a high speed centrifuge, and certain emulsions can be handled

satisfactorily. Crystalline materials can be drained freer from their mother liquor by a perforate-basket centrifuge than by a filter.

A Small Grease Kettle. ERIC A. BERGMANN, *The Texas Company, Beacon, N. Y., Ind. & Eng. Chem.*, **39** (1947) pp. 498-500.

A description is given of a cylindrical, flat-bottomed, laboratory grease kettle of approximately 4-liter capacity, heated by an oil jacket, through which oil is circulated, and stirred by a cylindrical pestle-type stirrer driven by a planetary mechanism. Preliminary work in a conventional steam-jacketed grease kettle of 2-gallon capacity with single-action paddle-type stirrer showed that this type of equipment was unsuitable, mainly because of excessive channeling of the stiff grease base, which led to poor mixing and uneven heat distribution. However the kettle described gave close temperature control, short manufacturing time cycles, a small charge, good reproducibility of batches, and ease of cleaning the apparatus. Efficiency of the pestle-stirred kettle is shown by the short processing time, which is ascribed to more efficient mixing; the result is more rapid dehydration and incorporation of oil, and other desirable features in grease manufacture.

Laboratory Machine for the Continuous Production of Grease; Development and Design. G. M. HAIN AND E. E. STONE. *Ind. & Eng. Chem.*, **39** (1947) pp. 506-7.

A machine is described for the continuous production of 100 pounds of grease per day in a totally enclosed system. When large batches of grease were made by this method, the laboratory ventilation proved inadequate, and much discomfort was experienced, since the vapors given off by the hot diester grease were irritable. This suggested the use of a closed system. A viscose spinnerete pump forced the material through the system. Soap was heated in a fluid slurry to 200° C. in a coil of fine-bore tubing, the walls of which were heated by a current of about 50 amperes. Cooling to a gel and shearing of the gel to a buttery grease were accomplished by forcing the hot liquid through a water-cooled coil of the same dimensions as the heater. Additional shearing took place in a worker section, using a gear pump to cycle grease through a perforated plate or screen. The greases produced were uniform and homogeneous and were as good as that produced by a much more laborious laboratory method. Quantities up to 50 pounds were made.

Flocculation and Peptization in Oil as Dispersion Medium. J. L. VAN DER MINNE. *Rec. trav. chim.*, **65** (1946) 549-55.

Lubricating oils were used as typical nonionized liquids in a study of the colloid chemistry of liquids of this type. When the suspended matter in used motor oils is coagulated, it is observed under the ultramicroscope to give loose strings in the course of several days at rom temperature, but in an hour at 95° with the lowered viscosity. Small quantities of phenolic substances cause a rapid coagulation through a dissolving action on sludge products of incomplete combustion. Peptizing agents, such as alkaline earth naphthenates, petroleum sulfonates, or phenylstearates, alkylated salicylates, or tall-oil salts, prevent floc-

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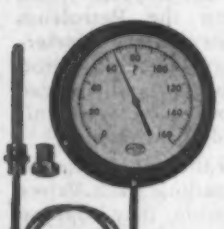

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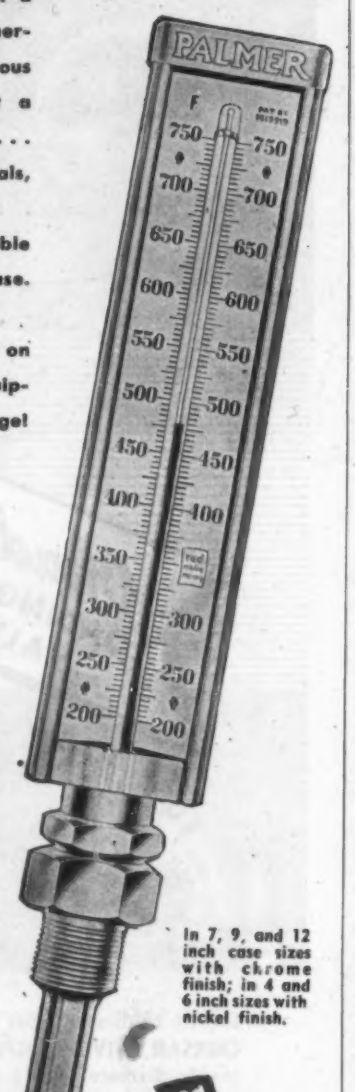

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culation of lacquer components in motor oils. Oil-soluble resins formed by oxidation of oil also peptize suspensions in oils. But small amounts of such resins and of sulfonates counteract each other, the former giving a negative charge to particles and the latter giving them a positive charge.

Products: Properties, Utilization and Analysis

Synthetic Lubricant Fluids from Branched-Chain Diesters. E. M. Bried, H. F. Kidder, C. M. Murphy, and W. A. Zisman. *Ind. & Eng. Chem.*, **39** (1947) pp. 484-91.

During the war it was found necessary to develop chemically stable and non-corrosive fluids having freezing and pour points below -40° F., low evaporation rates, and low viscosities at -40° F., as well as a low viscosity-temperature curve slope. These substances were used for lubricants in many special types of aviation and ordnance equipment and instruments. From structural analogies and known rules relating molecular structure of hydrocarbons to their physical properties, it was concluded that long-chain and essentially aliphatic diester molecules were needed having one or more short-chain alkyl branches suitably positioned. Thirty-four diesters were prepared, purified, and studied in the course of the research program. Properties studied were viscosity-temperature behavior, volatility, flammability, specific gravity, thermal expansion, solubility for water, and hydrolytic stability. From studies of the properties of these fluids, a small group was selected for development into lubricants for use. The best combination of properties was found for several types of diesters: (1) glutarates, adipates, azelates, and sebacates made with secondary anyl alcohol, 3-methylbutanol, 2-ethylhexanol, and the branched-chain secondary alcohols, undecanol and tetradecanol; (2) those made by reacting the above acids with 2-(2'-ethylbutoxy) ethanol; and (3) those made by reacting hexamethylene glycol or decamethylene glycol with a branched-chain acid such as 2-ethylhexanoic acid; and (4) those made by reacting triethylene glycol or a polyethylene glycol with 2-ethylhexanoic acid. The data secured in the work are presented in six tables, and a bibliography of twenty-three references is included.

Synthetic Lubricant Fluids from Branched-Chain Diesters Development of Additives and Lubricating Oil Compositions. D. C. Atkins, Jr., H. R. Baker, C. M. Murphy, and W. A. Zisman. *Ind. & Eng. Chem.*, **39** (1947) pp. 491-7.

The work reported in this paper is an extension of the work of the Naval Research Laboratory concerned with the oxidation and stability of selected diesters, and the development of antioxidants, rust inhibitors, and viscosity index improvers for lubricant compositions a number of instrument oil compositions were prepared with medium to high viscosity indices, low evaporation rates, and freezing points or pour points ranging from -40° to -100° F. Laboratory evaluation of these compositions reveals

that their oxidation stabilities are equal to or superior to petroleum oils of comparable viscosity. They also have good rust preventive properties, satisfactory demulsibilities, low water solubilities, and foaming tendencies. Laboratory preparations of the oils with viscosities of 10 to 15 centistokes at 100° F. have already been used by naval or cooperating industrial groups, and found to give superior performance to conventional lubricants over a wide range of temperatures in a variety of instruments and mechanisms. Possible applications of other viscosity grades are discussed.

Synthetic Low Temperature Greases From Aliphatic Diesters. G. M. HAIN, D. T. JONES, R. L. MERKER, AND W. A. ZISMAN. *Ind. & Eng. Chem.*, **39** (1947) pp. 500-6.

The authors describe the making of grease by dispersing various soaps in a number of aliphatic diester lubricating fluids described in other publications of the Naval Research Laboratory. Improvements desired in the grease included decreased torque requirements at temperatures below -40° F., lower evaporation rates, improved storage stability, and greater reproducibility. A series of greases suitable for lubrication at temperatures from -40 to -100° F. were prepared from aliphatic diesters thickened with lithium stearate. The products resemble in texture and working properties the present low temperature petroleum greases specified by the Army and Navy. However, the products have low evaporation rates and better storage stability than the usual products. The greases have good lubricating properties and excellent oxidation stability. The composition and properties of the greases are presented in considerable detail and the data secured in the work are given in 4 tables and 4 figures. A bibliography of 7 references is included.

Calculation of Weight Percent Ring and Number of Rings per Molecure for Aromatics. M. R. LIPKIN AND C. C. MARTIN. *Anal. Chem.*, **19** (1947) pp. 183-9.

The authors describe a procedure for the determination of the percent rings and average number of rings per molecule for solutions of alkyl hydrocarbons using density and density coefficient, which can be derived from mid-boiling point curve and density. The methods have been found to be accurate within 3 percent for rings and 0.1 percent ring per molecule when the procedure has been applied to pure compounds. Aromatics with naphthenic or olefinic side chains cause some interference but these compounds are usually not present in sufficient concentration to affect significantly the accuracy of the methods for petroleum fractions boiling below 400° C. Results of the work are presented in considerable detail in 6 figures and 10 tables and a bibliography of 23 references is included.

Determination of Olefins, Aromatics, Paraffins, and Naphthenes in Gasoline. S. S. KURTZ, JR., I. W. MILLS, C. C. MARTIN, W. T. HARVEY, AND M. R. LIPKIN. *Anal. Chem.*, **19** (1947) pp. 175-82.

The authors present a paper describing a method developed in the laboratories of the Sun Oil Company over a period of years that is suitable for the analysis of straight-run, polymer, catalytically cracked, and thermally cracked gasolines, including those that are rich in olefins and aromatics. The method is believed to have the advantage over methods previously available in that it is more reliable, particularly for samples rich in olefins and aromatics. This reliability results from improved procedures and from a system of internal cross checks that insure the accuracy of the analytical data obtained. The first step in the analysis of the gasoline is the fractionation into cuts of approximately 45° F. boiling range. The volume percent of unsaturated hydrocarbons is determined by acid-treating with a mixture of 30 percent by weight of phosphorous pentoxide and 70 percent by weight of 95 percent sulfuric acid. Olefinic unsaturates are determined by an improved bromide-bromate titration. The aromatic content of each cut is calculated by use of the specific dispersion and bromine number. A cross check of the data obtained in the first three steps is obtained by comparing the sum of the olefins plus aromatics with the unsaturates as first determined. If a check is not obtained the olefins are determined by the nitrogen tetroxide method. The saturated fractions remaining after removal of olefins and aromatics is analyzed for paraffins and naphthenes by means of physical properties. The procedures are described in considerable detail and typical results are presented in tabular form. A bibliography of six references is included.

Errors in Viscometry Due to Surface Tension. GUY BARR. *Proc. Phys. Soc., (London)* **58** (1946) 575-85.

Surface tension causes a reduction of the head available and increases the time of flow in viscometers of the Ostwald type as used for the determination of kinematic viscosities relative to water. The correction is greater for water than for organic liquids. However, it is not proportional to surface tension. Earlier estimates of the correction are questioned. The calculated corrections for two liquids with surface tensions differing rather more than those of water and benzene diverge by 0.5 percent when a mean head of 10 cm. is assumed, and a simple experiment demonstrates that this estimate is probably low, owing to effects of drainage on the shape of the meniscus. The author proposes two methods for eliminating the correction in the calibration of the viscometers.

Octane Ratings of Agricultural Motor Fuels. C. F. ELDER, F. R. TRUBY, AND RICHARD WIEBE. *Ind. Eng. Chem.*, **39** (1947) pp. 508-10.

In connection with the behavior of ethanol and other possible fermentation products in the internal combustion engine, octane ratings on a large number of blends (mostly anhydrous fuels) were determined. With few exceptions, the data reported were obtained with the F-2 method, since it is still the standard laboratory procedure for rating automotive fuels. However, alcohol is a sensitive fuel, and for a sensitive fuel the F-1 method appears to be a better indicator of road performance than the standard F-2 procedure. The F-1 rating of ethanol itself, is equal to isooctane plus 1.4 ml. of tetraethyl lead. Data are presented for the blends of ethanol with paraffins, isooctane, aromatics, and cyclohexane. Aniline is the most effective compound for raising the octane number of ethanol. Tetraethyl lead depresses the octane number of pure ethanol as well as some of the higher alcohols. For this reason it was important to know to what extent

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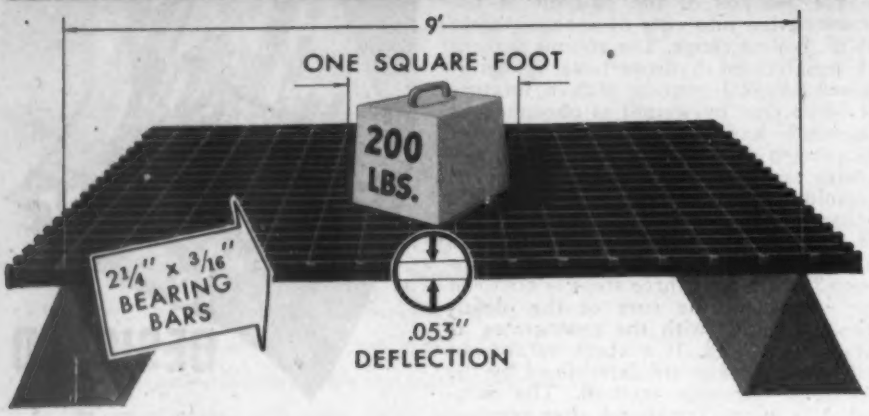

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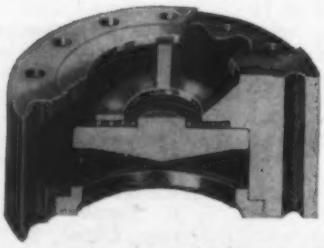

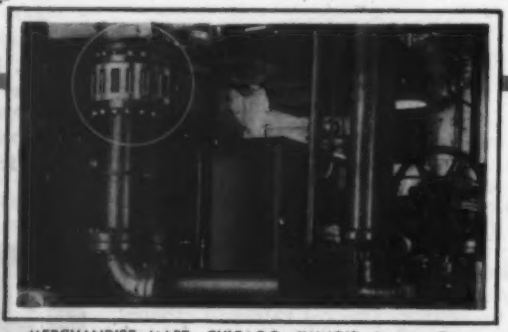

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such a detrimental effect persists in blends. Tables are given showing the F-2 Octane Numbers of Ethanol blended with the various hydrocarbons and with the aromatics and cyclohexane. Tetraethyl lead susceptibility of various alcohols, reference fluids, and blends is shown in a tabular presentation of results. The data are presented on the F-2 octane numbers of ethanol blended with alcohol, ketones, ethers and water. A bibliography of 11 references is included.

Spectroscopic Analysis: Application of the Hydrogen Discharge Lamp to the Analysis of Mixtures of C_8 Aromatic Hydrocarbons. R. I. GORDON, H. POWELL, AND J. TADAYYON, *Jour. Inst. of Petroleum*, **33** (1947) p 103.

Two methods of using the hydrogen discharge lamp employed by other workers are described and examples given. It is shown that neither of these methods gives accurate analyses. A third method has been developed that uses a microphotometer, and which makes possible a quantitative measure of the absorption at any wavelength. This method in its present stage of development is not so accurate as the Spekker method normally used, but it is believed that it may be made at least as accurate on further study. The method using the microphotometer is not so rapid as the Spekker method for the analysis of isolated samples, but is more rapid when analyses are required on a series of samples whose composition and concentration are known approximately.

Viscometry of Soap-in-Hydrocarbon Systems. G. F. WOOD, A. H. NISSAN, AND F. H. GARNER. *Jour. Inst. of Petroleum*, **33** (1947) pp. 71-102.

When metallic soaps of fatty or naphthenic acids are mixed with hydrocarbons and either mechanically or thermally treated to give solutions, it is possible to obtain practically all degrees of subdivision of the soap, from the ultimate molecular solution yielding a low-viscosity liquid on the one hand, to a swollen, opaque, soft solid on the other. The author reviews the factors that govern the properties of the final product. The capillary viscometry of soaps in solution in low-molecular-weight hydrocarbons was studied in particular detail, and certain aspects of rotary and falling sphere viscometers were found of interest in understanding the rheological behavior of such systems. It was concluded that these systems behave as if they possessed a retarding layer at the fluid-solid interface. These fluids behave in a way that implies extra loss of energy to that encountered in other pseudoplastic systems. This results in a high viscous-type energy loss at the entrance into a pipe, and also in certain complications in the flow pattern of the stream lines and resultant pressure losses which become significant in the rotary and capillary viscometers. When of sufficiently high concentration, these fluids reveal a definite yield value and recoil in short-period experiments. At low rates of flow, and when no yield value is evident, these fluids behave as if they were simple Newtonian liquids. In the region of low rates of flow, viscosities obtained by capillary and falling-sphere methods are not the same for the same fluid. The reasons for this are considered and discussed by the authors. A bibliography of 21 references is included.

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Iodine Value	90—93	91—95
Sap Value	197—201	197—201
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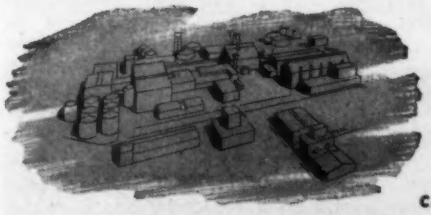

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U.S.P. 2,417,355. Distillation of Hydrocarbons with Addition of Acetone-Methyl Alcohol. G. A. Dummett and S. J. Ralph to The Aluminum Plant & Vessel Company, Ltd., London.

A mixture boiling between 95-125° C. and containing about 60 percent of aromatic hydrocarbons mixed with the paraffins, naphthenes and unsaturated hydrocarbons and inseparable by simple distillation, is distilled at a lower flux ratio with the continuous addition of an entraining agent consisting of 1.5-2 volumes of an acetone-methyl alcohol azeotrope. A head fraction of very high non-aromatic content is taken off. A true azeotropic distillation with another entraining agent follows. By the indicated pseudo-azeotropic distillation a more economic separation is obtained than by using a truly azeotropic distillation from the beginning.

U.S.P. 2,417,637. Process for Removing Impurities from Oils. H. C. Eddy to Petrolite Corporation, Ltd.

Water-soluble and water-wettable impurities are removed from mineral oils by first mixing the oil with relatively fresh water to form an emulsion while using a mixing action more intense than that which will permit complete resolution of the emulsion into oil and water in the succeeding step. The emulsion is then partially resolved to form an oil containing a small amount of dispersed water and a sludge relatively rich in water and comprising a concentrated emulsion of water in oil. Proportioned amounts of the sludge and of the relatively fresh water are mixed to form a new emulsion. This emulsion is subjected to the atcion of an electrical field of sufficient intensity to coalesce the water droplets of the emulsion while sufficient oil is present in the field to permit maintenance of high voltage gradients therein. The coalesced water is separated.

U.S.P. 2,417,669. Distillation of Hydrogen Fluoride-Hydrocarbon Mixtures at Constant Rate. R. E. Vinyard to Phillips Petroleum Co.

A mixture containing low-boiling hydrocarbons, such as isobutane, and HF, as for example obtained in the alkylation of low-boiling paraffins in the presence of HF, is passed to a fractionating zone at constant flow rate. An overhead product comprising essentially all HF together with at least sufficient low-boiling hydrocarbon material to form a minimum-boiling azeotropic mixture with the HF is separated at a positively controlled constant flow rate. A higher-boiling hydrocarbon fraction is withdrawn as bottom product from the fractionating zone. Sufficient heat to maintain constant pressure at a point in the fractionating zone is supplied to the bottom of this zone.

U.S.P. 2,417,738, 2,417,739, 2,417,740. Process for Breaking Petroleum Emulsions. M. De Groote to Petrolite Corporation, Ltd.

According to U. S. Patent 2,417,738 a petroleum emulsion of the water-in-oil type is treated with an acidic partial ester obtained by reaction between a polycarboxy acid, such as phthalic acid, adipic acid, or diglycollic acid, and dimerized 9,11-linolo-diricinolein. The emulsion is resolved by this treatment.

According to U. S. Patent 2,417,739 a drastically oxidized dimer of the 9,11-linolo-diricinolein is employed, and according to U. S. Patent 2,417,740 a hydroxyacetylated and drastically oxidized dimer of the 9,11-linolo-diricinolein is employed for the same purpose. The oxidation is in both cases effected by means of an oxygen-containing gas.

U.S.P. 2,418,093. Reaction Between Hydrocarbon Chloride and Isobutylene. R. P. Perkins and R. H. Rigterink to The Dow Chemical Company.

A mixture of isobutylene- and butadiene-containing hydrocarbons of the C_4 series is treated in the liquid phase with anhydrous HCl in the presence of a bleaching clay and at a temperature of about 10-50° C. The isobutylene is thereby selectively reacted with the HCl to form tert. Butyl chloride, and the isobutylene can thus be selectively removed from the butadiene containing mixture of C_4 hydrocarbons.

U.S.P. 2,418,183. Prevention of Emulsions During Extraction of Olefins With Metal Salt Solutions. H. R. McCombie and R. L. Kittle to Shell Development Company.

Olefins, such as butadiene, are separated from fluid mixtures containing also aldehyde impurities by washing the mixture, e.g. a hydrocarbon mixture, with aqueous ammonia which is a non-solvent for unsaturated hydrocarbons. The olefins are then extracted from the remaining mixture with a solution of a heavy metal salt capable of forming reversible complexes with the olefins, such as an aqueous copper ammonium acetate solution. The formation of obnoxious emulsions during this extraction is decreased or inhibited by the preliminary removal of the aldehydes formed in the cracking of hydrocarbons.

U.S.P. 2,418,391. Method of Increasing Octane Number of Motor Fuel. G. W. Ayers to The Pure Oil Company.

Paraffinic hydrocarbons boiling in the gasoline range are contacted for a period of at least 2 days with potassium cyanide, cuprous cyanide, nickel cyanide, mercuric cyanide, or silver cyanide, whereafter the hydrocarbons are separated from the cyanide which is insoluble in the hydrocarbon. The anti-knock value of the hydrocarbons when used in ignition-type internal combustion engines is improved by the process. The cyanide can be employed in amounts of about 10 percent by weight of the hydrocarbons to be treated.

U.S.P. 2,418,784. Process of Acid Refining Viscous Hydrocarbon Oil. D. M. McCormick, C. B. Barbour, and W. K. Griesinger to The Atlantic Refining Company.

Viscous hydrocarbon oil is contacted with H_2SO_4 in the presence of an added small amount of a surface tension reducing agent sufficient to render the acid sludge produced readily pumpable. The resultant sludge is allowed to settle and is separated from the oil. An alkali metal salt of an aliphatic carboxylic acid, e.g. 0.0025-0.0125 percent of a higher fatty acid in aqueous solution, can be used as the tension reducing agent.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,417,664. Silica-Beryllia Gel. A. C. Schmitt to Socony-Vacuum Oil Company, Inc.

A hydrosol containing silica and beryllia is prepared by first forming a silica hydrosol, adding an aqueous solution of a soluble compound of Be, and adding an aqueous buffer solution to the resultant mixture. The amounts and acidity of the hydrosol and the two aqueous solutions are so adjusted that the pH of the final mixture shall be between 5 and 8.5 sodium beryllate solution and a solution of ammonium acetate for buffering can be used. The composition of mixture obtained is preferably maintained constant until it sets to a firm hydrogel.

U.S.P. 2,417,359. Carbon Removal and Regenerative Gas Requirements in Catalyst Reactivation. J. A. Guyer to Phillips Petroleum Company.

A bed of porous granular catalyst deactivated by deposition of a major pro-

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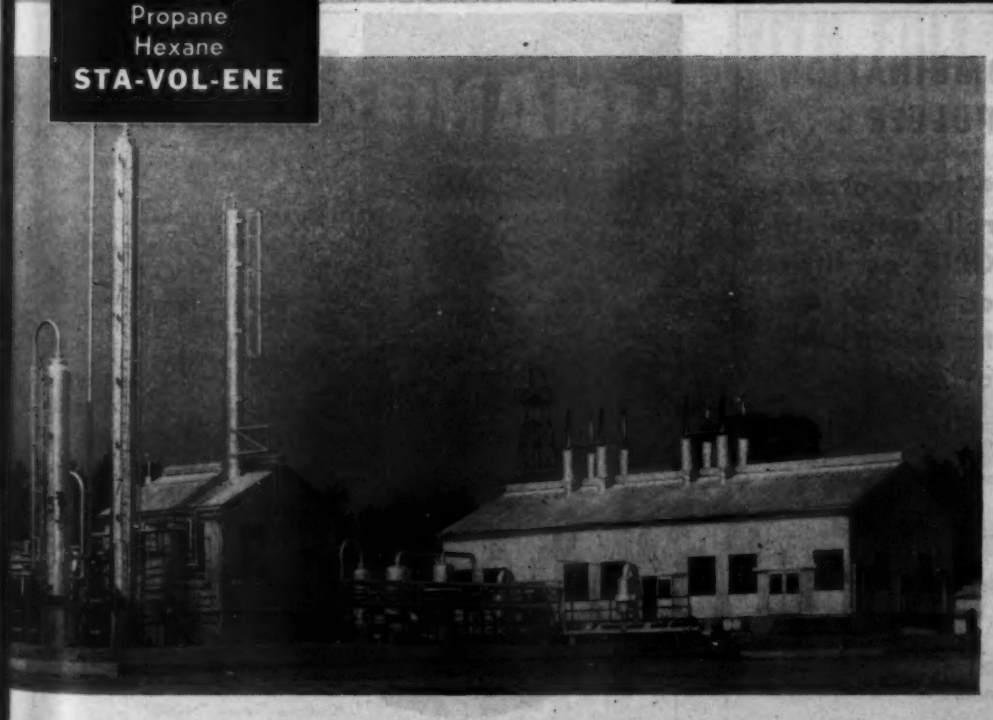

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portion of carbonaceous material on the surface and a minor proportion of carbonaceous material within the pores of the catalyst is treated by flowing an oxygen-containing gas under combustion conditions through said bed until the major proportion of the carbonaceous material is completely burned off in a first regenerative stage and free oxygen begins to appear in the spent regeneration gas. The flow of the oxygen-containing gas is then continued in a second regenerative stage until the effluent regeneration gas contains from 10-40 percent as much O_2 as is present in the gas introduced into the catalyst bed. The carbonaceous material deposited within the pores of the catalyst is uniformly burned off during this second stage of the process.

U.S.P. 2,417,275. Regeneration of Powdered Catalyst. W. J. Thompson and D. L. Campbell to Standard Oil Development Company.

Finely divided powdered material contaminated with carbonaceous deposits is suspended in a gaseous medium containing only sufficient oxygen to partially regenerate the material by combustion of the deposits. This suspension is passed under suitable condition of temperature, pressure and time through a combustion zone. It is then cooled, and the process is repeated with addition of oxygen-containing gas in each of several succeeding combustion zones until the desired regeneration is effected. A part of the suspension is withdrawn from a portion of the regeneration system between a combustion vessel and a succeeding cooler. Catalyst is separated from this suspension and returned to a previous portion of the regeneration system including a combustion zone. The recycled catalyst can be suspended in air before returning it to the system.

U.S.P. 2,418,232. Process of Preparing An Inorganic Oxide Gel. M. M. Marisic to Socony-Vacuum Oil Company, Inc.

Inorganic oxide gel particles of spheroidal shape are formed by extruding an aqueous sol capable of setting to a hydrogel and having a solid phase of inorganic oxides, into a body of a liquid immiscible with the sol, such as hydrocarbon oil, and maintained at a temperature higher than the temperature of the sol but below the boiling point of the sol. Globules of sol are formed and heated in the liquid to reduce the gelation time. The globules remain in the liquid until gelation occurs.

U.S.P. 2,418,270. Preparation of Catalysts Comprising Supported Chromium Oxide. M. P. Matuszak to Phillips Petroleum Company.

A hydrosol is formed by the addition of a conc. aqueous ammonia solution of a water-soluble chromium salt of a monobasic acid, such as chromium nitrate, in an amount approximately two thirds of the stoichiometrical equivalent of this salt and less than the amount required to form a permanent precipitate. A porous granular catalyst-carrier is impregnated with this hydrosol. A substantial portion of the excess liquid is then removed and the resulting material is dried. Thereafter it is heated at about 250-600° C. in a current of superheated steam containing about 5-15 percent by volume of molecular hydrogen. The catalyst material thus obtained is particularly useful in the dehydrogenation of hydrocarbons to yield unsaturated hydrocarbons of the same number of C atoms.

U.S.P. 2,418,309. Chromium Oxide Catalyst and Its Method of Preparation. M. P. Matuszak and G. H. Morey to Phillips Petroleum Company.

The process according to this patent is similar to that of U.S.P. 2,418,270. An ammonium-containing salt of chromic acid is used in the present case for impregnating the solid granular carrier, which is then dried and subjected to controlled heating in a reducing atmosphere at a temperature below that at which the salt decomposes with incandescence, to effect its non-spontaneous decomposition and concomitant reduction to chromium oxide. A black, unglowed chromium oxide having a ratio of Cr to O_2 corresponding to the empirical formula CrO_2 is thus formed on the carrier.

U.S.P. 2,418,346. Preparation of Metallic Halide-Hydrocarbon Complex Catalyst. G. F. Gruenke to The Texas Company.

A stream of normally liquid non-aromatic hydrocarbon, e.g. kerosine, is passed in liquid phase through a stationary mass of solid metallic halide, such as $AlCl_3$, at about 150-250° F. for a contact time of 1-5 minutes. A solution of metallic halide in the hydrocarbon is thus formed without substantial complex formation. The resultant stream is passed together with added hydrogen halide into an intermediate portion of an unpacked reaction zone where the mixture is left at said elevated temperature for at least 30 minutes under compara-

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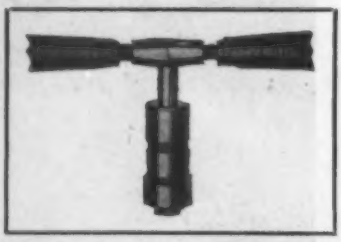

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tively quiescent conditions. Complete complex formation is effected and the complex liquid settles to the bottom of the reaction zone while a hydrocarbon phase substantially free of complex is formed in an upper part of this zone. A stream of active metallic halide-hydrocarbon complex liquid is withdrawn as a final product from the lower part of this zone. A stream of the hydrocarbon phase withdrawn from an upper portion of the zone substantially above the level of the intermediate inlet portion thereof is recycled directly through a heater and thence to the zone of contact with the solid metallic halide.

CRACKING AND REFORMING

U.S.P. 2,417,054. Catalysis. G. R. Bond to Houdry Process Corporation.

Lower boiling hydrocarbons, of the gasoline range, are produced from heavy hydrocarbon oil having a 50 percent point above 650° F. by cracking this oil in the presence of a composite comprising silica, alumina, and beryllia, in which silica is predominant and beryllia is present in an amount of 1-20 percent. The composite is prepared by coprecipitation of the hydrous compounds.

U.S.P. 2,417,105. Method for Cracking Hydrocarbons in the Presence of the Halogen, Bromine and Iodine, and a Chlorinated Unsaturated Aliphatic Organic Compound. H. O. Folkins to The Pure Oil Company.

Hydrocarbons are cracked under suitable conditions of time, temperature, and pressure in the presence of a small amount of Br or I and a small amount of an organic compound having a chlorinated, unsaturated, aliphatic group. The amount of the halogen employed is preferably at least .005 mol percent and that of the organic compound at least .05 mol percent. Allyl chloride and methylallyl chloride are examples of suitable organic compounds. A cracking temperature of 375-750° C. is preferably used.

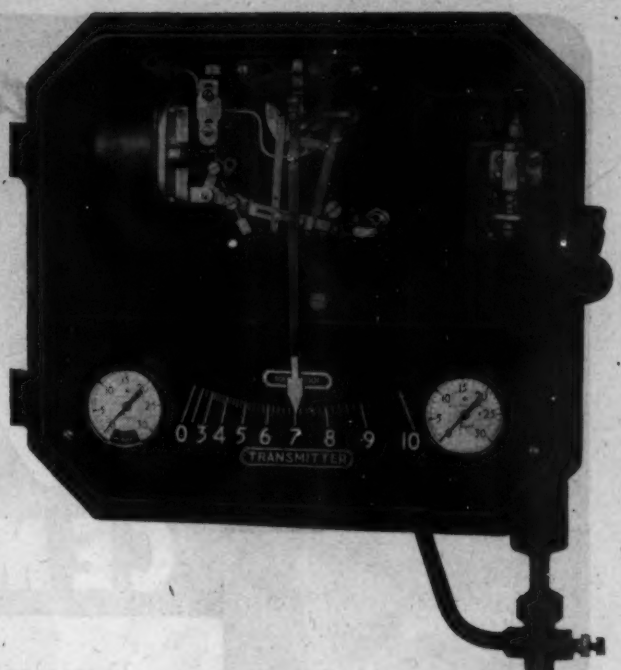
U.S.P. 2,417,280. Production of Butadiene. P. S. Viles to Standard Oil Development Company.

A feed stock formed from a petroleum distillate fraction and including an appreciable amount of peroxides, as, for example, obtained by allowing a distilled naphtha fraction boiling in the range of 180-350° F. to stand in a tank exposed to an oxygen-containing atmosphere for a protracted period of time, is contacted with lead mercaptide in an amount at least sufficient to react with substantially all peroxide and reactive sulfur compounds in the feed stock. The material is then redistilled to form a non-corrosive distillate fraction free of organic peroxides and reactive sulfur compounds and a bottom fraction. The distillate fraction is cracked at about 1300° F. to form butadiene. The preceding removal of the peroxides eliminates or reduces the corrosion of the metal equipment in the high-temperature cracking of petroleum distillates.

U.S.P. 2,417,393. Apparatus for Hydrocarbon Reaction. L. P. Evans to Socony-Vacuum Oil Company, Inc.

A shell enclosing a reaction zone has inlet means to feed particle-form solid contact mass thereto and outlet means for this mass. A plurality of vertical partitions is disposed in pairs within the reaction zone. The members of each pair are arranged to provide gas spaces there-

NEW



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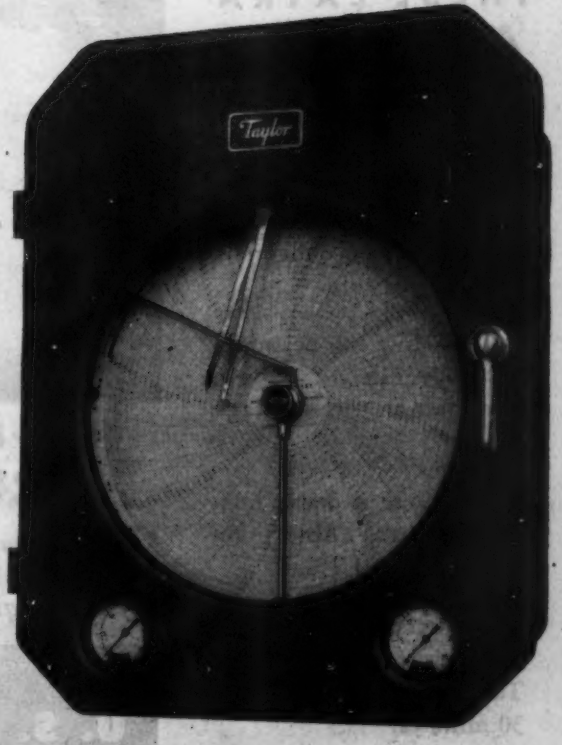

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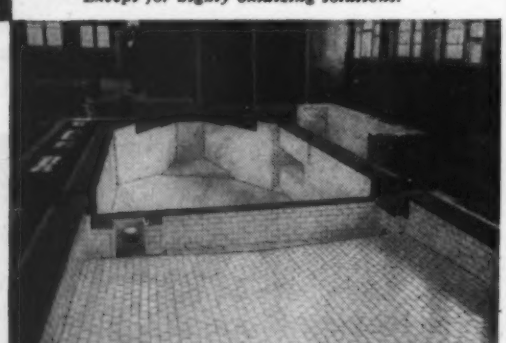

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between and the pairs of partitions are arranged to provide passages therebetween wherein contact mass flows. Means are provided adjacent the upper ends of the partitions to exclude flow of solid material into the gas spaces. Gaseous reactant inlet means are communicating with certain of the gas spaces while corresponding outlet means are communicating with the other gas spaces. The space-defining partitions have therein foraminate areas whereby gaseous reactant may flow from reactant inlet means into contact mass and thence to reactant outlet means. The foraminate areas are adapted to substantially exclude flow of the contact material particles into the gas spaces. The contact mass passages between the pairs of partitions are of substantial length in proportion to their width and the reactant-outlet foraminate areas are spaced away from the reactant-inlet foraminate areas. The flow of gaseous reactant through the column of solid is substantially parallel to the direction of the column.

U.S.P. 2,417,867. Cracking Hydrocarbon Oils. S. C. Fulton, C. O. Tongberg, and E. D. Reeves to Standard Oil Development Company.

Hydrocarbon oil is passed through a heating and vaporizing zone. The resulting vapors are contacted with finely divided solid conversion catalyst, such as acid treated bentonite, at a conversion temperature (e.g. 850° F.). The catalyst is maintained in suspension in the oil vapors for a period sufficient to obtain a substantial conversion of the oil (e.g. for 25 seconds). The major portion of the catalyst is then separated from the conversion products at a temperature above the dew point of the vaporous products which are then cooled to form an initial oil condensate containing the remainder of the catalyst. This condensate is combined with the feed oil prior to passing it to the conversion zone. The catalyst separated earlier from the oil is regenerated.

ISOMERIZATION

U.S.P. 2,417,187. Catalytic Isomerization of Saturated Hydrocarbons in the Presence of An Halide-Hydrocarbon Complex Saturated With Aluminum Halide. J. R. Callaway to The Texas Company.

A static column of active liquid isomerization catalyst consisting of aluminum halide-hydrocarbon complex formed by reacting aluminum halide with a portion of the saturated hydrocarbons to be isomerized is maintained in a reaction tower. The complex liquid is saturated with aluminum halide but free from suspended solid aluminum halide. A freed stream of saturated non-aromatic hydrocarbons, e.g. n-butane, to be treated is continuously injected into the lower portion of said static column and dispersed in discontinuous phase upwardly through this liquid column of catalyst in continuous phase by difference in density in the presence of hydrogen halide not exceeding about 5 percent by weight of the hydrocarbon feed and at an elevated temperature not exceeding 240° F., so that isomerization of the hydrocarbons to more highly branched saturated non-aromatic hydrocarbons constitutes the principal reaction. The liquid volume of the catalyst in the tower is maintained greater than

that of the treated hydrocarbons. The depth of catalyst liquid through which the dispersed hydrocarbons rise is maintained within the range of about 10-60 feet. The time of contact of the dispersed hydrocarbons with the catalyst shall not exceed 10 minutes. An effluent hydrocarbon stream issuing from the top of the catalyst column contains the isomerized product.

U.S.P. 2,417,201. Process of Isomerizing Saturated Low Boiling Feed Hydrocarbons. F. Horton to The Texas Company.

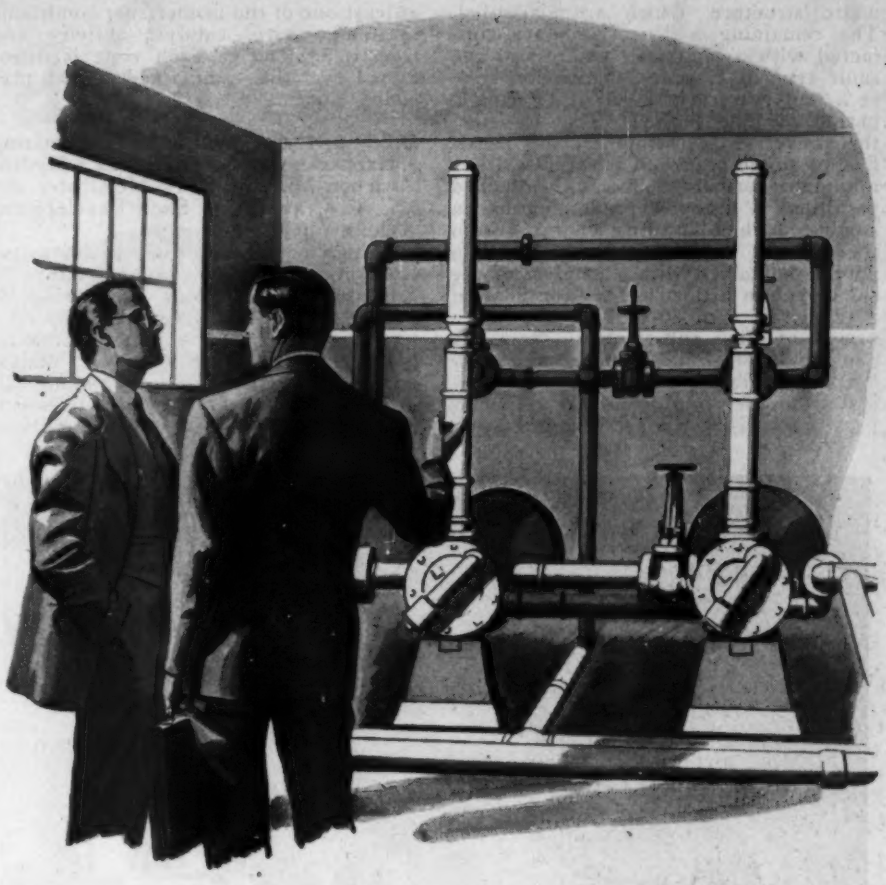
The process according to this patent is similar to that of patent 2,417,187. An effluent liquid stream of the treated material including isomerized hydrocarbons and hydrogen halide but free from metallic halide is continuously withdrawn from the upper portion of the reaction zone at a point above the catalyst column. This effluent stream is fractionated to strip therefrom a gaseous fraction consisting mainly of hydrogen halide and a small amount of fixed hydrocarbon gas. This gaseous fraction is passed through a scrubbing zone and countercurrently contacted therein with a stream of feed hydrocarbon in liquid phase, e.g. n-butane, so that hydrogen halide is dissolved in this stream. The undissolved fixed gas is discharged. The stream with the dissolved hydrogen halide is injected into the lower portion of the catalyst column. A separate liquid stream of feed hydrocarbon comprising n-butane is contacted with solid hydrogen halide under conditions such that a small amount of metallic halide is dissolved therein. This stream is separately injected into the lower portion of the catalyst column at a point removed from that at which the first named stream is injected. Used complex is withdrawn from the upper portion of said column. The amount of metallic halide injected is regulated so as to maintain the complex catalyst within the reaction zone at a predetermined level of activity and free from solid metal halide.

U.S.P. 2,417,221. Catalytic Isomerization. W. R. Smith to The Texas Company.

This process is similar to that of U.S.P. 2,417,187. The isomerization temperature shall not exceed 300° F. and the height of the catalyst column shall be such that substantial isomerization occurs in a single passage of the feed hydrocarbons. Metallic halide is introduced to the catalyst column in an amount such that the complex is maintained at a predetermined level of activity and is characterized by having an absolute heat of hydrolysis in the range of substantially above 213 to about 341 calories per gram of complex.

U.S.P. 2,417,698. Isomerizing Hydrocarbons. S. H. McAllister, C. C. Crawford, and W. E. Ross to Shell Development Company.

Multibranched paraffins, such as dimethylbutane, are produced from hydrocarbon mixtures comprising straight chain paraffins with at least 6 C atoms, such as n-hexane, and naphthene hydrocarbons of non-hydroaromatic structure with the same number of C atoms such as methylclopentane, by contacting the hydrocarbon mixture with a partially spent aluminum halide-containing isomerization catalyst of the molten salt type in a first conversion zone at a temperature not substantially in excess of 80° C. in the presence of a hydrogen halide promoter. The naphthenes are converted to naphthenes of hydroaro-



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matic structure, which are separated. The remaining hydrocarbons are contacted with a non-spent catalyst of the same type in a second conversion zone at a temperature of 80-90° C. during a period of time limited so as to effect the conversion of straight chain paraffins to single-branched paraffins with a minimum formation of multi-branched paraffins. A fraction predominating in single-branched paraffins separated from the effluent of the second conversion zone is contacted with a catalyst of the same type in a third conversion zone at a temperature of 80-125° C. and for a period of time sufficient to effect the conversion of single-branched to multi-branched paraffins. Partially spent catalyst from the second and third zone is passed to the first zone. An increase in at least one of the isomerizing conditions of temperature, catalyst activity and time of contact in each zone is maintained over that maintained in each preceding zone.

U.S.P. 2,417,699. Method for Isomerizing Naphthenes and Paraffins in a Hydrocarbon Mixture. S. H. McAllister and C. C. Crawford to Shell Development Company.

A high octane paraffinic hydrocarbon fraction is obtained from a mixture of saturated hydrocarbons comprising n-hexane and methylcyclopentane by contacting this mixture with an aluminum halide-hydrocarbon complex catalyst substantially free of free aluminum halide in a first conversion zone under sufficiently mild isomerization conditions to effect the conversion of methylcyclopentane to cyclohexane as the predominating reaction. Naphthenes comprising cyclohexane are then separated from the hydrocarbon mixture which thereafter is contacted with an aluminum halide-containing isomerization catalyst of the molten salt type in a second conversion zone under paraffin isomerizing conditions.

U.S.P. 2,417,875. Removal of Hydrogen Fluoride from Water. A. B. Leonhard to Phillips Petroleum Company.

In the conversion of hydrocarbons in the presence of an HF catalyst, e.g., in the alkylation of low-boiling isoparaffin, the reaction effluents are passed to a separating zone where liquid HF is separated from hydrocarbons. At least a portion of this liquid HF is treated in a distillation zone to separate therefrom as a low-boiling fraction purified HF, which is returned to the conversion, and as a high-boiling fraction aqueous HF together with heavy organic material. The latter fraction is fractionally distilled in the presence of added low-boiling olefin to form a low-boiling fluorine containing fraction and high-boiling fraction containing undesired impurities. Water is removed from the low-boiling fluorine containing fraction, and the resulting water-free fraction is passed to conversion.

U.S.P. 2,418,724. Isomerization of Saturated Hydrocarbons. H. Pines and R. C. Wackher to Universal Oil Products Company.

A normally liquid paraffin hydrocarbon, such as n-pentane, and a phenolic compound containing a hydrocarbon substitutent, e.g. tertiary butyl phenol or cyclohexyl phenol, are contacted with a Friedel-Crafts type isomerization catalyst under isomerizing conditions. The presence of relatively minor amounts of such phenolic compounds suppresses decomposition reactions of the saturated hydrocarbons and permits their isomerization with a high degree of efficiency and low catalyst consumption.

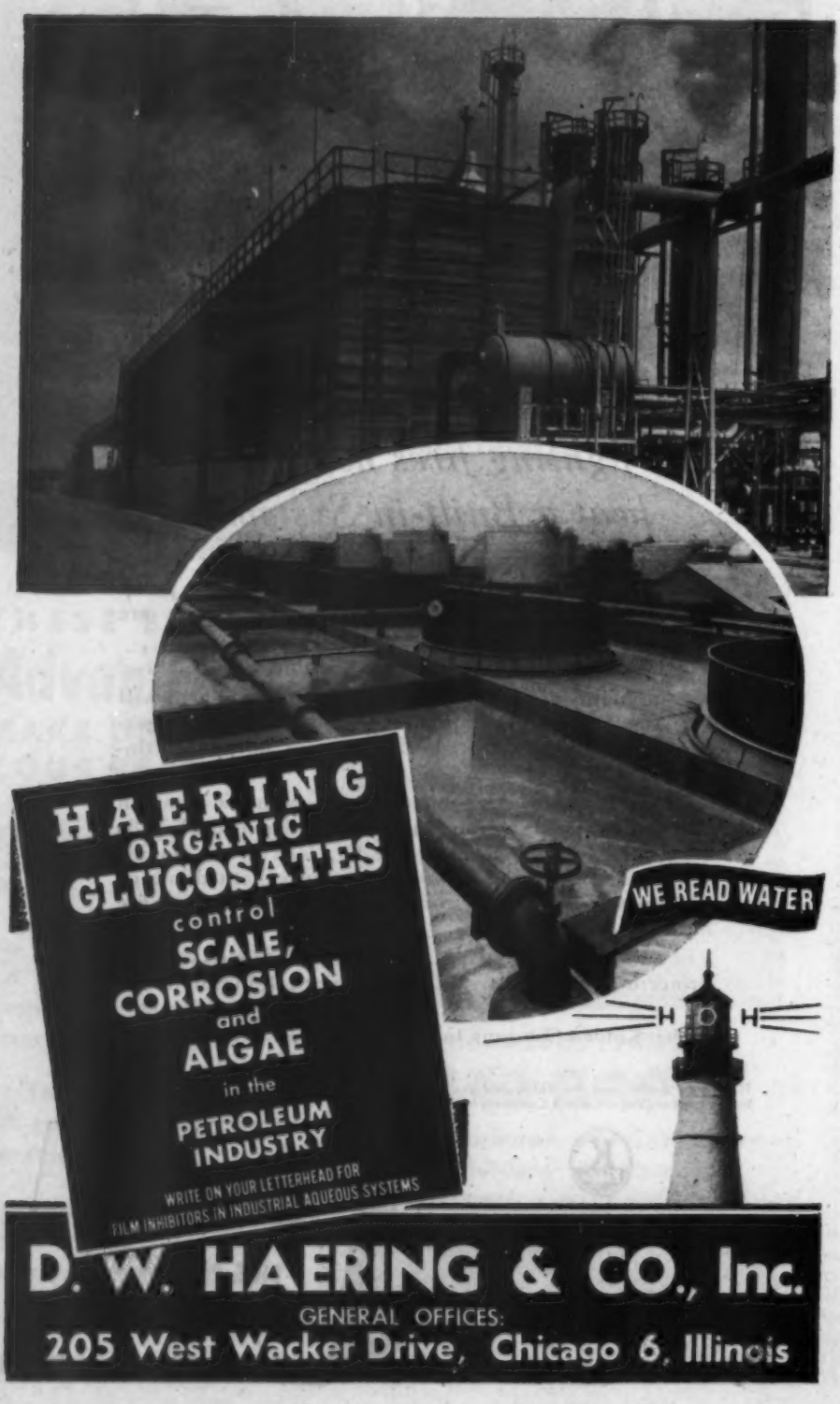
ALKYLATION

U.S.P. 2,417,119. Synthesis of Olefins by Reacting an Olefin With an Alkyl Halide in the Presence of Calcium Oxide. V. A. Miller & W. G. Lovell to General Motors Corporation.

An olefin is treated with a halide of an alkyl radical to be introduced into the olefin in a position adjacent to the double bond under pressures upwards of 5000 psi and at temperatures upwards of 200° C. in the presence of a metal oxide capable of reacting with the halide under the conditions employed. Tetramethylene can, for example, be reacted with methyl chloride in the presence of CaO at 210-240° C. under a pressure of 500-1500 psi.

U.S.P. 2,417,106. Decrease of Organic Fluorine Compounds in Hydrofluoric Acid Alkylation of Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

A mixture of an alkylatable hydrocarbon and an alkylating reactant is reacted in the presence of anhydrous HF. At least a part of the reaction mixture is recycled to the alkylation zone and the mixture is then maintained under alkylating conditions for an additional period of time. The reaction mixture is thereafter separated into a liquid hydro-



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carbon phase and a liquid acid phase. The acid phase is digested under alkylating conditions and the acid phase and hydrocarbon phase are recontacted under alkylating conditions. The resulting mixture is again separated into a hydrocarbon phase and an acid phase. The acid phase is recycled to the alkylating zone, and the hydrocarbon phase is fractionated to obtain a normally liquid paraffinic material. Due to the separate treatment of the acid phase organic fluorine compounds dissolved therein are completely consumed by alkylation of alkylatable compounds present.

U.S.P. 2,417,251. Alkylation Process. C. E. Hemminger to Standard Oil Development Company.

A hydrocarbon fraction containing C_4 to C_7 olefins is converted into substantially saturated hydrocarbons boiling in the gasoline range by alkylating the C_4 olefins of the fraction with isobutane in the presence of conc. H_2SO_4 of alkylation strength in a first stage and alkylating the C_3 and C_5 to C_7 olefins of the fraction with isobutane in the presence of less concentrated H_2SO_4 of alkylation strength at a temperature above 35° F. in a second stage. The external isoparaffin to olefin ratio is maintained lower in the second than in the first stage.

U.S.P. 2,417,454. Synthesis of Ethylated Aromatic Compounds. B. B. Corson and L. J. Brady to Koppers Company, Inc.

An ethyl derivative of aromatic hydrocarbon, such as monoethyl benzene, is synthesized by passing a mixture of aromatic hydrocarbon and ethylene free of higher mol weight olefin in a molar ratio of aromatic hydrocarbon to ethylene greater than 1:1, continuously through a solid phosphoric acid alkylating catalyst for a period of 14-145 seconds, at a temperature of 260-315° C., and at a pressure of 200-900 psi. Product is continuously withdrawn from contact with the catalyst, the mono-ethylated aromatic compound is separated from the mixture, and the residual ethylene is recycled to the alkylation zone. Poly-ethylated aromatic hydrocarbons which are simultaneously formed, can, after separation from the mono-ethylated compounds, be returned in admixture with non-ethylated aromatic hydrocarbon into contact with the catalyst to convert poly-ethylated into less ethylated aromatics.

U.S.P. 2,418,028. Condensation of Hydrocarbons. V. Haensel to Universal Oil Products Company.

An alkylatable hydrocarbon, such as an aromatic hydrocarbon or an isoparaffin, is subjected together with an olefin under alkylating conditions to the action of a catalyst which comprises an association of refractory oxides of at least two elements from the group consisting of Si, Al, Zr, Mg, Th, and B in the presence of a minor amount of an organic carboxylic acid consisting of C, H, and O, e.g. of CH_3COOH.

U.S.P. 2,418,210. Process for Treating Alkylation Sulfuric Acid Sludge. C. B. Wilde to Stauffer Chemical Company.

A waste sulfuric acid derived from an alkylation process and containing about 67-80 percent acid, water and hydrocarbonaceous material is maintained in the raw, unhydrolized state at a temperature of about 305-315° F. under atmospheric pressure to coagulate the hydrocar-

bonaceous material into a solid, coke-like granular residue which is separated from the acid. The acid can then be fortified to about 98 percent strength and freed from any remaining carbon content by further heating to 600-620° F.

U.S.P. 2,418,689. Production of Alkylated Aromatic Hydrocarbons. W. L. Benedict and W. J. Mattox to Universal Oil Products Company.

A dialkyl aromatic hydrocarbon, such as xylene or diethyl benzene, is produced by reacting a mono-alkyl aromatic hydrocarbon, such as toluene or monoethyl benzene, in the presence of a silica alumina composite catalyst at a temperature of 200-700° C. and an hourly weight space velocity of 0.1-10.

POLYMERIZATION AND CONVERSION

U.S.P. 2,417,527. Conversion of Hydrocarbon Oils. W. J. Sweeney to Standard Oil Development Company.

Higher boiling oils are converted into aviation gasoline of low acid heat by cracking the oil in the presence of a catalyst at a temperature of 850-1000° F. for a period sufficient to convert at least 40 percent of the oil into other constituents. The products are fractionated to segregate a light naphtha fraction boiling principally below 200° F., an intermediate naphtha fraction boiling between 200-300° F., and a heavier naphtha fraction. The heavier and the light fractions are combined and further treated in the presence of the same catalyst at a temperature lower than that of the first cracking operation. This treatment is effected for a period sufficient to materially reduce the acid heat of the product. The treated product is fractionated to segregate the desired aviation gasoline therefrom. If desired, the light fraction from the first treatment only may be subjected to the second treatment and the product thus obtained then be combined with the heavy fraction of the first treatment.

U.S.P. 2,417,872. Process for Preparing a Dimethyl Butene from Propylene. R. M. Hill and H. G. Codet to Standard Oil Development Company.

A gas feed consisting essentially of C_3 hydrocarbons including at least predominant amounts of propylene is subjected in a combined isomerization-polymerization reaction to the action of a catalyst which contains about 2-12 percent by weight of $AlCl_3$ sorbed on an alumina which has previously been partially dehydrated by calcination to a water content of less than 4 percent. A reaction temperature of about 350° F. and a throughput of about 1-1.5 liquid volumes of propylene per volume of catalyst per hour are employed. A pressure of about 350 psi is maintained during the reaction. Dimethyl substituted C_4 hydrocarbons, such as 2,2-dimethyl butene, are obtained.

U.S.P. 2,417,973. Process for the Catalytic Conversion of Hydrocarbon Oils. W. J. Degnen to The M. W. Kellogg Company.

Vapors of hydrocarbons to be converted are contacted at elevated temperature with a catalyst while continuously supplying particles of the catalyst to a catalyst supply conduit intercommunicating with the conversion zone. The hydrocarbon vapors are admitted to the conduit at a point down stream from said supply point to produce a gaseous dispersion of the particles. The particles are compacted in the conduit between the said two points to produce a seal. The dispersion thus produced is passed upwardly through a conversion zone of relatively large cross-section, wherein the vapor velocity is sufficiently low to cause a cloud-like formation of catalyst particles and a portion of the dispersed catalyst to settle out at the bottom of the zone. Vaporous conversion products and catalyst particles dispersed therein are withdrawn from the upper portion of the conversion zone and passed at a relative high velocity to a separating zone where the catalyst is separated from the vapors.

U.S.P. 2,418,003. Catalytic Conversion of Fluid Reactants. C. H. Angell to Universal Oil Products Company.

Hydrocarbons to be converted are passed upwardly through a lower extended region of a reaction zone at a sufficiently high velocity to carry the solid particles of catalytic material within said zone upwardly into a higher region of this zone. A sufficient temperature and a sufficient concentration of active catalyst particles are maintained in said lower region to effect substantial conversion of the hydrocarbons during their passage through this region. A relatively dense turbulent bed of catalyst particles is maintained in said higher region. The hydrocarbons and solid particles are discharged from the lower region into the lower portion of said dense turbulent bed, reducing the upward velocity of the hydrocarbons in the higher region sufficiently to effect substantial hindered settling of the solid particles therein. The higher region is also maintained under conversion conditions to effect further conversion of the hydrocarbons. Regulated quantities of the catalyst are returned directly from the higher region to a relatively low point of the lower region. A higher catalyst concentration is maintained in the turbulent bed of the higher region than in the lower region of the reaction zone. A siliceous cracking catalyst or a dehydrogenating catalyst for the dehydrogenation of normally gaseous hydrocarbons, or an aromatizing catalyst for the aromatization of hydrocarbons boiling within the gasoline range, can, for example, be employed in the process.

U.S.P. 2,418,023. Catalytic Reconstruction of Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

Olefinic hydrocarbons are converted to more highly saturated hydrocarbons by subjecting the olefins to the action of a substantial amount of free hydrogen in the presence of and intimately admixed with liquid conc. HF as the essential catalyst under conversion conditions. A hydrocarbon to catalyst ratio in the range of 0.1:1 to 3:1 by weight is maintained. Isobutane can, for example, be produced by this process from n-butene, the free hydrogen being preferably employed under a pressure of at least 200 psi. The catalyst can comprise 0.1-10 percent by weight of BF_3.

U.S.P. 2,418,146. Catalytic Conversion. J. D. Upham to Phillips Petroleum Company.

Within a single vertical fractional distillation column there is provided a stripping section in its lower part, a higher isomerization zone containing a permeable bed of lump anhydrous Friedel-Crafts metal halide isomerization

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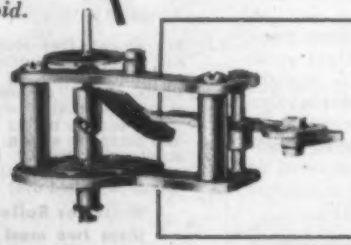

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catalyst, and a still higher distillation zone containing a permeable bed of solid contact particles. The isomerization and alkylation zones include respectively the point of maximum normal paraffin concentration and the point of maximum isoparaffin concentration. Temperature and pressure conditions throughout the column are maintained to effect fractional distillation therein and effect isomerization and alkylation in the respective zones. A low-boiling olefin, such as methylene or butylene, is introduced into the alkylation zone and a low-boiling normal paraffin, e.g. n-butane, into the column in an amount to provide at least sufficient isoparaffin to react with the olefin by alkylation. Active metal halide sludge is withdrawn from the isomerization zone, passed upwardly by entrainment in a portion of the feed hydrocarbons, and discharged at a point above the bed of contact particles for flow downwardly thereover as the active alkylation catalyst. Spent sludge from the alkylation zone is withdrawn. Promoter is present in the isomerization and alkylation zone in sufficient concentration to promote the reactions. The isoparaffin formed in the isomerization zone is caused to pass upwardly by vaporization and rectification in the column to the alkylation zone, where it is alkylated with the olefin. The resulting alkylate is caused to flow downwardly in the column to the stripping section. Unreacted normal paraffin is vaporized from alkylate in the stripping zone. The vapors are returned to the isomerization zone. A high isoparaffin-olefin ratio is maintained in the alkylation zone. Light gases are withdrawn overhead from the column, cooled and condensed. The condensate formed is returned to the top of the column as reflux to aid the fractionation and to remove heat of isomerization and of alkylation. A stabilized normally liquid hydrocarbon fraction comprising branched-chain saturated hydrocarbons is withdrawn as the product from the stripping section. It is suitable as aviation fuel and has a high octane number.

U. S. P. 2,418,419. Metal Halide Catalysis of Hydrocarbons. J. M. Mavity to Universal Oil Products Company.

A relatively small amount of an organoaluminum compound of the formula R_nAlx_{3-n} wherein R represents an alkyl or aryl hydrocarbon radical, X represents Cl, Br, or I, and n is an integer not greater than 3, is added to the hydrocarbons prior to their contact in liquid phase with a bulk supply of a Friedel-Crafts metal halide catalyst therein. The resultant solution is then supplied in the usual manner to a reaction zone for the conversion, e.g. the isomerization or alkylation, of hydrocarbons. Methyl aluminum sesquichloride can, for example, be added to the hydrocarbons in an amount of 0.1 percent by weight. The formation of a dark viscous liquid lower layer of sludge otherwise found in the catalyst supply tower is inhibited and the loss in metal halide otherwise caused by sludge formation is avoided.

U.S.P. 2,418,672. Method and Apparatus for Hydrocarbon Conversion. E. L. Sinclair and W. A. Hagerbaumer to Socony-Vacuum Oil Company, Inc.

Hydrocarbon reactants in the gaseous form are passed at a constant, fixed volumetric velocity through a confined reaction zone to contact a continuously

moving particle-formed catalyst passed through this zone in the form of a substantially compact column of a fixed and constant length. The reactant space velocity is changed without variation of the length of the column of a catalyst within the reaction zone. For this purpose the reactant charge is selectively conducted as a single stream through varying fractional portions of the total column length of active catalyst while an inert gas atmosphere is maintained in the remaining unused portion of the column. The length of said fractional portions is varied in inverse proportion to the desired reactant space velocities.

U.S.P. 2,418,673. Method for Catalytic Conversion of Hydrocarbons. E. L. Sinclair and W. A. Hagerbaumer to Socony-Vacuum Oil Company, Inc.

A particle-form solid contact mass material is flown as a compact, uninterrupted downwardly moving column of constant cross-section through a confined reaction zone. One hydrocarbon reactant is introduced to flow through only a portion of the length of the contact mass column, while a second hydrocarbon reactant of different nature is introduced to flow through another portion of the column spaced apart from the first. Passage of either reactant into the portion utilized for the other reaction is prevented by so controlling the pressure relationship in the two portions of the contact mass column as to prevent the existence between the two portions of a pressure differential sufficient to cause flow of either reactant through the portion of the column lying between the two. Two or more related conversions of hydrocarbons can thus be effected simultaneously by means of the same contact mass column.

U.S.P. 2,418,679. Method and Apparatus for Hydrocarbon Conversion. E. Utterback to Socony-Vacuum Oil Company, Inc.

A particle-form solid catalyst is cyclically passed through separate conversion and regeneration zones as a compact downwardly flowing column while hydrocarbon vapors heated to the desired conversion temperature are passed through the moving catalyst in the conversion zone. Combustion supporting gas is passed through the regeneration zone at a rate sufficient to completely burn all contaminant deposited upon the catalyst. Flow of the hydrocarbon vapors into the regeneration zone and flow of the combustion supporting gas into the conversion zone is prevented. At least the major portion of the heat liberated by the combustion of the contaminants is removed prior to the return of the regenerated moving catalyst to the reaction zone. The rate of cyclic catalyst flow is controlled so as to prevent the temperature of the catalyst in passing through the regeneration zone from rising above a predetermined fixed maximum. The process can be used for the hydrogenation, alkylation, or cracking of hydrocarbons.

U.S.P. 2,418,797. Continuous Process for Polymerizing Olefins. V. Vorhees to Standard Oil Company of Indiana.

A film of an unsaturated hydrocarbon liquid, such as isobutylene, is continuously moved on a moving surface within a catalyst polymerization zone in the presence of an atmosphere of a polymerization zone in the presence of an

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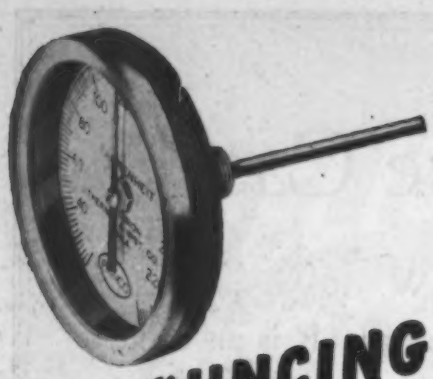

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atmosphere of a polymerization catalyst, such as BF_3. The film is maintained at a controlled low temperature, e.g. -10° C., during the reaction by indirectly refrigerating that part of the area of the film where the polymerization occurs, with sufficient refrigerating fluid to absorb the heat of polymerization. A film of high mol weight polymers is thus produced which is removed from the reaction zone.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,417,164. Hydrocarbon Synthesis. H. E. Huber to Standard Oil Company of Indiana.

Gasoline hydrocarbons are produced by reacting a mixture of hydrogen and CO in the ratio of less than about 2:1 in the presence of a fluidized iron catalyst under a substantially superatmospheric pressure and a temperature above 400° F. From the reaction products of this first stage a gaseous fraction including unreacted hydrogen and CO in the ratio of about 2:1 is supplied to a second reaction stage where the mixture is contacted with a cobalt catalyst at superatmospheric pressure and at a temperature of 340-500° F. A heavier-than-gasoline product fraction, a gasoline hydrocarbon fraction, and a gaseous fraction are recovered from the reaction products of the second stage. The yield of hydrocarbons rich in olefins is increased by this improved process.

U.S.P. 2,418,255. Catalytic Dehydrogenation of Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

A reactant material, such as a mixture of low boiling hydrocarbons of at least 2 C atoms, is subject to such conditions of elevated temperature and time of heating as to effect a partial thermal conversion. Suitable conditions are a temperature of 1000-1300° F. under a pressure not greater than 100 psi applied for a period of time sufficient to effect a production of 5-15 percent of olefin by hydrogenation. The effluent containing the olefin is subjected without separation or substantial reduction of temperature to the action of a series of contact masses substantjally free from heat-exchange relationship with temperature-controlling means to effect endothermic reactions, such as further dehydrogenation, while simultaneoulsly cooling the treated material. Portion of the partially converted material are added at elevated temperature to the reactions at a point between successive contact masses.

U.S.P. 2,418,374. Process for the Production of Alkadienes. C. M. Stone to The Texas Company.

A mixture of mono-olefinic hydrocarbon, such as butene-2, with SO_3 and an inert diluent which is gaseous at the reaction temperature, such as water, or concentrated or aqueous H_2SO_4, is contacted with a copper sulfate catalyst adsorbed on Al_2O_3 at a temperature of 800-1300° F. for a short period of time. The olefinic hydrocarbon is converted to an alkadiene, e.g. butadiene, while avoiding substantial cracking. The contact period can, for example, range from about 0.1-2.0 seconds and the pressure maintained in the reaction zone is preferably such that the sum of the partial pressures of the mono-olefin employed and the SO_3 is substantially below atmospheric pressure.

U.S.P. 2,418,441. Hydrogenation of Organic Compounds Using Titanium Hydride as a Catalyst. G. M. Whitman to E. I. du Pont de Nemours & Company.

An unsaturated organic compound containing a triple bond between C and an element with an atomic weight of from 12-15 is heated with hydrogen in the presence of titanium hydride as a catalyst, to hydrogenate the organic compound. The process can, for example, be used in the production of styrene from phenyl-acetylene. A temperature of 100-225° C., a pressure of more than 1000 psi and an amount of 1-10 percent of the hydride on the basis of the hydrocarbon employed, can be used in this case.

U.S.P. 2,418,534. Hydrocarbon Conversion Process. C. W. Watson to The Texas Company.

Gasoline rich in aromatic hydrocarbons and saturated aliphatic hydrocarbons is continuously prepared from straight run and cracked naphtha hydrocarbons boiling within the range 100-300° F. and containing sulfur-bearing compounds in substantial amount. Straight-run hydrocarbons continuously flow first through a dehydrogenation section of a stationary mass of hydrogenation-dehydrogenation catalyst in an elongated reaction zone, and thereafter through a hydrogenation section of this zone. Treatment in the dehydrogenation zone is effected at a temperature of 840-870° F. under a pressure of 400-800 psi and with a space velocity of 0.1-0.5 liquid volumes of naphtha per hour per volume of catalyst, and in the absence of olefinic constituents of the cracked naphtha hydrocarbons so that dehydrogenation of the hydro-aromatic constituents present occurs with liberation of hydrogen in substantial amount. Cracked hydrocarbons are continuously introduced to the hydrogenating section of the reaction zone. The products of the aforesaid dehydrogenation and the introduced cracked hydrocarbons are caused to flow concurrently and in direct contact through the hydrogenating section at an elevated temperature not in excess of 800° F., e.g. at 650-700° F., and with a space velocity of 1-3 liquid volumes of combined naphtha per volume of catalyst per hour so that hydrogenation of cracked hydrocarbons with said liberated hydrogen occurs. The proportion of straight run hydrocarbons to cracked hydrocarbons charged is correlated so that the cyclic hydrocarbons are about 1.1-1.5 times the mol equivalent of the olefins and that free hydrogen in substantial amount is maintained in the reaction zone. The flow of hydrocarbons through the reaction zone is continued for over 100 hours without catalyst regeneration. Hydrocarbon products and free hydrogen are continuously discharged from the reaction zone. The liquid hydrocarbons contained in these products amount to at least 98 percent by weight of the combined naphtha feed, and the C_5 hydrocarbon and lighter constituents of the product consist of not less than 97 percent by weight of hydrogen. Gas is separated from the discharged products, heated and then introduced at a plurality of succeeding points in the dehydrogenating section of the reaction zone to maintain substantially uniform temperature throughout the section. The catalyst may be of the molybdena-alumina type.

DESULFURIZATION

U.S.P. 2,417,041. Removal of Sulfur Compounds from Hydrocarbon Oils. G. W. Ayers, D. M. Barton, and E. E. Harton to The Pure Oil Company.

Hydrocarbon oil containing mercaptans or organic disulfides is contacted in liquid phase at temperatures not substantially above 100° C. with a solid reagent resulting from the action at atmospheric or lower temperatures of an aqueous alkali solution on an alloy containing Al, Si, Be, or Zn and Ni or Cu. The treatment removes or reduces the sulfur contained in the oil.

U.S.P. 2,417,308. Desulfurization and Hydroforming. M. W. Lee to Union Oil Company.

A volatile hydrocarbon feed mixture containing S-compounds is subjected to vapor phase catalytic desulfurization at a temperature between 600-850° F. The resulting gaseous mixture is subjected without removal of any of its constituents to vapor phase hydroforming with a different catalyst in a succeeding stage at a temperature between 850-1500° F. The operation in both stages is carried out under increased pressure in the presence of hydrogen in an amount greater than 100 cbm feet per barrel of liquid feet. Cobalt molybdate can be used as the desulfurization catalyst, and MoO_3 or Cr_2O_3 as the hydroforming catalyst. A cracked S-containing naphtha boiling below 500° F. can, for example, be treated by this process.

U.S.P. 2,418,047. Process for the Removal of Carbon Disulfide from a Hydrocarbon Liquid. D. W. Parkes and I. A. M. Ford to Robinson Brothers, Ltd.

A hydrocarbon liquid containing CS_2 is reacted with dimethylamine in aqueous solution in an amount substantially the molar equivalent of the CS_2 to be removed. The resultant mixture is allowed to settle. The aqueous solution containing the amine dithiocarbamate formed is separated from the hydrocarbon liquid. The dimethylamine is recovered from the aqueous solution, for example, by treating the aqueous solution successively with an acid and lime, or with lime and steam to expell the dimethylamine.

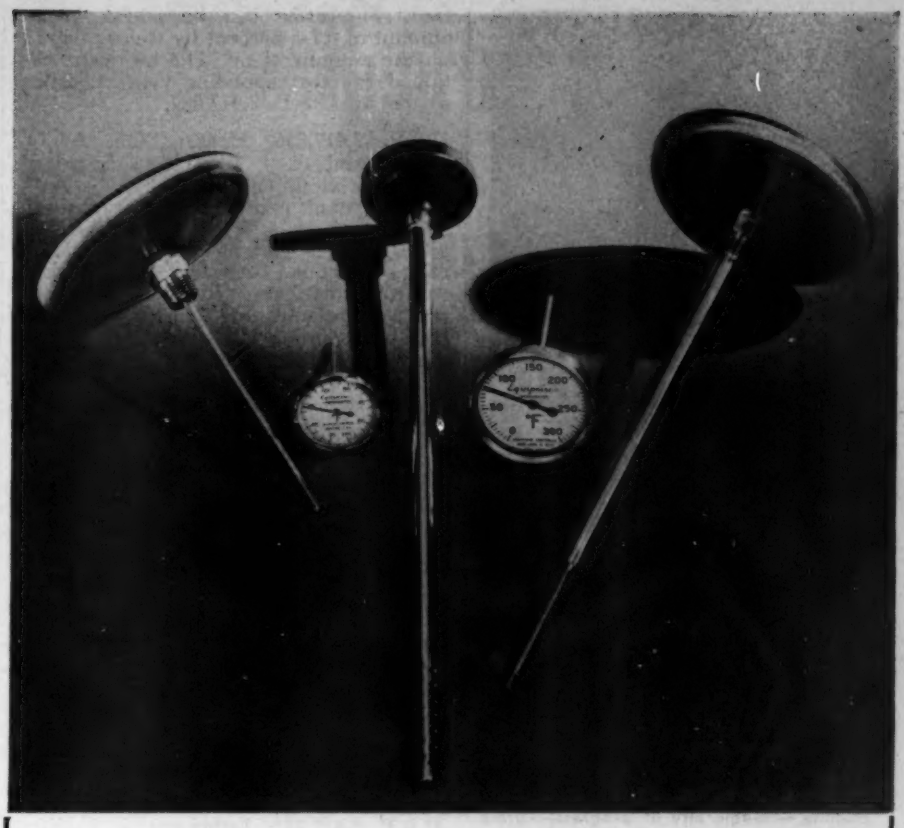
HEAVY OILS AND WAXES

U.S.P. 2,417,087. Lubricant. C. F. Prutton to The Lubri-Zol Corporation.

A major proportion of mineral lubricating oil is mixed with an aromatic compound (preferably from .001-20 percent) which contains (a) an aromatic nucleus, (b) an aliphatic substituent with more than 3 C atoms, and (c) an inorganic substituent containing O or S. An extreme pressure lubricant having increased load carrying capacity results. Seizure and scoring of the bearing lubricant is prevented by the added composition when the lubricant is operated under conditions of boundary lubrication.

U.S.P. 2,417,088. Lubricating Composition. C. F. Prutton to The Lubri-Zol Development Corporation.

The lubricating composition comprises the combination of an ester of a naphthenic acid, such as methyl naphthenate, and an organic sulfur compound, such as chor benzyl sulfide. A base hydrocarbon oil, preferably a mineral lubricating oil, is used in connection with said composi-



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tion. The ester can be added in an amount of 0.1-5 percent by weight, based on the amount of oil. The lubricant obtained has corresponding characteristics as that of U.S.P. 2,417,087.

U.S.P. 2,417,236. Heating Oil. A. Q. Cato and A. J. Shmidl to Standard Oil Development Company.

The patent relates to a composition to be used as a distillate-type heating oil. The composition comprises chemically unrefined catalytically cracked naphtha distillate, chemically refined crude petroleum and thermally cracked naphtha distillates, boils within the range of 350-700° F. and has a Tag-Robinson color no less than of the order of 15 after being subjected to storage under atmospheric temperature for approximately six weeks.

U.S.P. 2,417,264. Lubricant. A. J. Morway and J. C. Zimmer to Standard Oil Development Company.

The lubricating grease composition according to this patent comprises a low pour point lubricating mineral oil distillate, 10-20 percent of a neutral to basic lithium soap of saturated fats or saturated fatty acids containing not more than 0.1 percent alkali calculated as NaOH and 1-2 percent of a zinc or tin soap. A lithium soap of hydrogenated fish oil acids and zinc or tin oleates or naphthenates are, for example, employed.

U.S.P. 2,417,283. Lubricant. J. C. Zimmer and G. M. McNulty to Standard Oil Development Company.

A mineral lubricating oil is mixed with a cosulfurized blend of tall oil and an ester of a monohydric alcohol of at least 10 C atoms with a high mol weight fatty acid, such as cetyl or lauryl oleate. A sulfurzide cutting oil or extreme pressure lubricant is obtained the sulfur content of which insures improved lubricating qualities of the oil.

U.S.P. 2,417,305. Lubricating Oil and Method of Lubricating. E. C. Knowles, F. C. McCoy, and J. A. Patterson to The Texas Company.

A lubricant adapted for use in internal combustion engines comprises a mineral lubricating oil having incorporated therein a small amount (e.g. 0.25-3 percent) of a sulfurized monocyclic terpene hydrocarbon sufficient to impart corrosion inhibiting properties to the oil. A small amount (e.g. 0.25-2 percent) of an ingredient possessing detergent properties and sufficient to inhibit the lacquer and varnish-forming tendencies of the oil can also be added.

U.S.P. 2,417,415. Hydrocarbon Treatment. E. C. Hughes to The Standard Oil Company of Pennsylvania.

The motor fuel according to this patent comprises a mixture of a diesel fuel and the reaction product of a cycle gas oil reacted with about 20 percent of P_2S_5 at a temperature of about 350° F. The additive is used in an amount of about 2 percent based on the mixture.

U.S.P. 2,417,428. Lubricating Composition. L. W. McLennan to Union Oil Company.

A mineral oil, metal soap and a basically reacting metal compound are mixed. An amount of a low mol weight carboxylic acid sufficient to neutralize a portion of said metal compound is added. The resultant mixture is contacted with CO_2 to neutralize the remaining basically reacting compound

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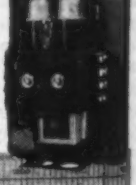

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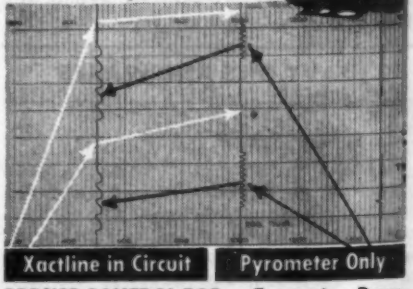

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and to form a metal soap complex. Stable lubricating greases of excellent melting point and penetration characteristics are produced by the addition of such a complex. A metal of group II or VIII of the periodic table can, for example, be employed in the basic metal compound.

U.S.P. 2,417,429. Complex Basic Soap Greases. L. W. McLennan to Union Oil Company.

The lubricating composition according to this patent comprises mineral oil and a metal soap complex which contains atoms of at least two different metals at least one of which is polyvalent. The ratio of equivalents of metals to equivalents of saponified high mol weight organic acids in this complex is between 1.1 and 4. The complex is substantially free from readily titrable excess alkalinity. The ratio of equivalents of the different metals is between 0.1 and 3.0. The two different metals can, for example, be: barium and sodium, or barium and aluminum, or magnesium and sodium. (Co&eF.: U.S.P. 2,417,428.)

U.S.P. 2,417,430, 2,417,431. Lubricants. L. W. McLennan to Union Oil Company.

The lubricating compositions acording to these patents are similar to that of U.S.P. 2,417,429. The soap complex according to U.S.P. 2,417,430 is a molecular strontium soap complex of the same ratio of equivalents of metal and organic acid as described before. According to U.S.P. 2,417,431 a magnesium soap complex of corresponding combination is used.

U.S.P. 2,417,432. Lubricants. L. W. McLennan to Union Oil Company.

The lubricating composition which is similar to those of U.S.P. 2,417,428-431 contains a calcium soap composition which is made by reacting in the presence of an excess of oxygen one equivalent of a basically reacting calcium compound with one equivalent of a saponifiable material.

U.S.P. 2,417,433. Lubricating Composition. L. W. McLennan to Union Oil Company.

The lubricating composition which is similar to those of U.S.P. 2,417,428-432 contains a barium soap complex which comprises a normal barium soap and a barium salt and in which the ratio of equivalents of barium salt to equivalents of normal barium soap is between about 0.1 and 3.

U.S.P. 2,417,562. Lubricant. J. R. Morris to The Texas Company.

The lubricant comprises a hydrocarbon oil and 0.01-5.0 percent by weight of an oil soluble metal salt of a S-containing acid of P possessing at least one ester radical derived from an unsaturated alky phenol which is derived from a member of the Anacardium genus of the Anacardiaceae family, such as cardanol, or cashew nut shell oil. This lubricant is resistant to oxidation and corrosion during service.

U.S.P. 2,417,826, 2,417,827. Lubricating Composition. W. A. Jones to Continental Oil Company.

A mineral oil of lubricating viscosity is incorporated with about 1-5 percent of the product of reaction at elevated temperatures of an unsaturated hydrocarbon and the material derived by fusing together a metal sulfide, such as

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calcium sulfide or copper sulfide, a phosphorous sulfide, such as P_2S_5, and elemental S. The lubricating composition obtained does not oxidize in use even under severe conditions.

According to U. S. Patent 2,417,827 an organic tetrathiophosphate, such as a calcium, barium, or tin salt, is employed for the same purpose, preferably in a quantity of about 0.001-1.0 percent of the oil.

U.S.P. 2,417,833. Lubricant. B. H. Lincoln and J. M. Hersh to Continental Oil Company.

A major portion of a lubricating oil is incorporated with a minor proportion of an aliphatic diacid of 6-12 C atoms, said acid having terminal carboxyl groups which are substituted with a silicon containing radical. The lubricating characteristics of the oil are improved by this addition. A metal ester of azelaic acid with at least one of the carboxylic groups substituted by a silicon containing group can, for example, be used as the additive.

U.S.P. 2,417,876. Inhibited Oil. A. W. Lewis and J. E. Schott to Tide Water Associated Oil Company.

The motor lubricating oil composition according to the patent comprises a major proportion of a hydrocarbon lubricating oil, a minor proportion of a thiophosphoric acid bearing corrosion inhibiting material, and a sufficient amount of a sulfonic acid substance effective to inhibit the rusting of ferrous metal motor parts. The sulfonic acid substance, such as an oil-soluble alkali or alkaline earth metal sulfonate, and the bearing corrosion inhibiting material, such as a metal salt of an organic thiophosphoric ester, shall be present in a weight ratio of not less than 4:1.

U.S.P. 2,418,358. Lubricating Oil. B. H. Lincoln and G. D. Byrkit to Continental Oil Company.

A major proportion of hydrocarbon oil is compounded with a minor proportion, e.g. 0.001-10 percent, of an organic boron compound of the general formula R_2BOR' or $RB(OR)_2$ in which R and R' are organic radicals at least one of which contains a carboxylic ester group. Phosphorus or sulfur can also be contained in said organic radicals. Thiocarboxyamylmethyl amylborate can, for example, be used for this purpose. The lubricant is thus stabilized against formation of corrosive oxidation products or sludge forming compounds.

U.S.P. 2,418,422. Lubricant. R. C. Palmer to Sinclair Refining Company.

A major portion of mineral oil is blended with about 14-35 percent of calcium petroleum sulfonate and about 0.7-3 percent of a mixture of mono-and di-(diamylphenyl) phosphates. The lubricant obtained is of special utility in inhibiting corrosion or rusting of metals during use.

U.S.P. 2,418,629. Aromatic Hydrocarbons and Their Halogen Derivates as Antifoggants. G. E. Fallesen to Eastman Kodak Company.

A non-waxy aromatic hydrocarbon of the benzene series having either a halogen, or an unsubstituted phenyl radical, or unsubstituted lower alkyl radicals as substituents is used as an ingredient in gelatino-silver halide photographic emulsions to inhibit fog formation.

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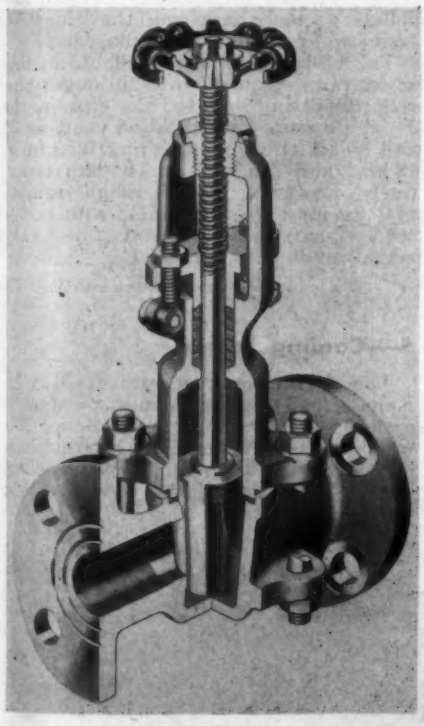
1—Plug Gate Valves

Crane Company, 836 South Michigan Avenue, announced a new line of corrosion resistant plug gate valves, which have been so designed that they provide straight through flow in the wide open position as do conventional gate valves, while they combine facilities for throttling action similar to globe valves.



Crane Plug Valve

The new valves have outside screw and yoke design with bolted bonnet joints and are available with either screwed or flanged ends in sizes from ½ inch to 2 inches. They are regularly furnished in either 18-8 Mo or Monel metal. For particularly corrosive conditions they also can be made in other alloys to specifications.

CHECK THE CARD AT PAGE 229

2—Stainless Steel Spargers

The Micro Metallic Corporation, 193 Bradford Street, Brooklyn 7, announces the addition to its line of stainless steel filters of a range of standard sizes of industrial gas dispersion units.

These units consist of a disc of porous stainless steel, which is welded about its periphery to a shallow stainless steel dish. The dish is welded to a standard female pipe connection. In use the required number of pipe connections are provided at the bottom of the tank, and the spargers are then screwed into place.

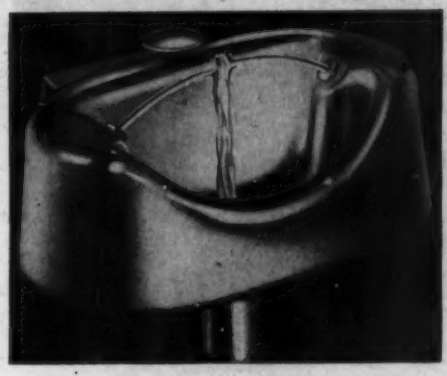
The porous stainless steel elements are available in fine porosities, ranging from 5 to 65 microns. The finer grades yield a large volume of very fine gas bubbles. Flow capacities for all the grades are high, and are accompanied by unusually low pressure drops, compared with thicker and less uniform dispersion media.

CHECK THE CARD AT PAGE 229

3—Eye Washer

Benson & Associates, 332 South Michigan Avenue, Chicago 4, Illinois, is offering a washing foundation for flushing the eyes for counteracting vapors or for removal of dust, chemicals or smoke. It is so designed that copious amounts of water strike the entire eye area.

It is essentially a double foundation with standard inlet and drainage connections. The openings are so arranged that two streams of water are simultaneously directed against the eyes. Water pressure can be regulated so that a soft stream is produced assuring a copious but easy flow. The cast aluminum bowl is designed to fit the upper contours of the face. The actuating valve is operated merely by resting the head on the upper portion of the bowl; this type of operation makes it necessary to keep the eyes in the ideal range of the streams of water. In addition it allows freedom of the hands to spread the eyelids apart assuring contact of the water with every portion of the eye tissues which have been contacted by foreign substances. A pressure regulator is built into the actuating valve. The unit has a dual function, serving as a drinking fountain or eye washer. Its construction permits both indoor and outdoor installation.

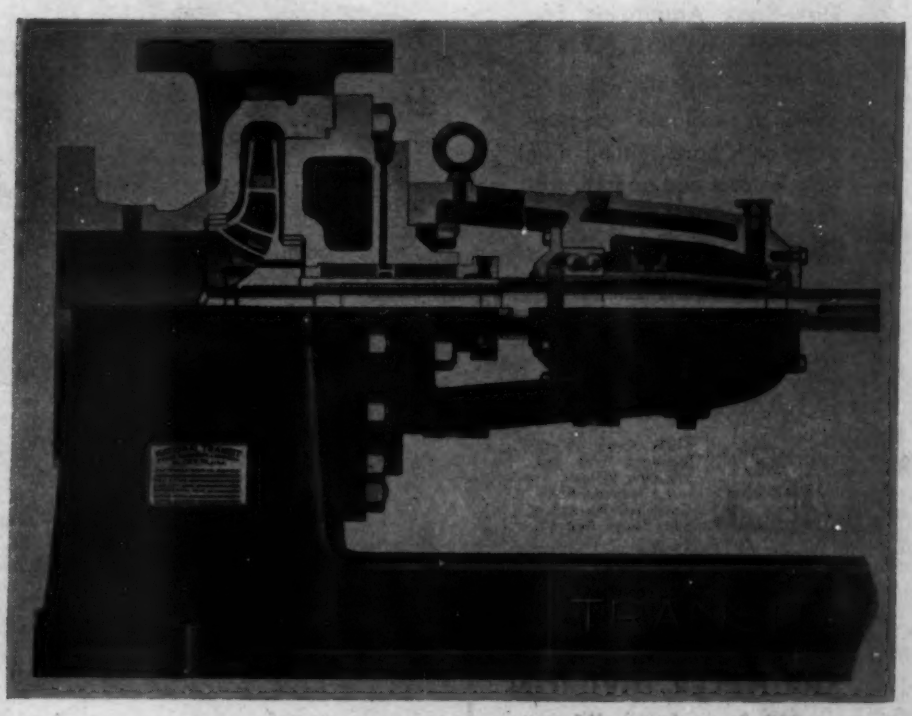


Eye Washing Fountain

CHECK THE CARD AT PAGE 229

4—Centrifugal Pump

National Transit Pump and Machine Company, Oil City, Pennsylvania, has introduced a new design centrifugal pump for process unit applications. The new line is an outboard bearing type with vertically split case. Capacities range from 40 to 1500 gallons per minute at differential heads varying from 40 to 1000 feet, and at speeds from 1750 to 4000 revolutions per minute. Allowable operating pressures for steel case



National Transit Centrifugal Pump

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pumps are 1000 psi at 100° F. or 500 psi at 800° F., and for cast iron case pumps 600 psi at 100° F. or 500 psi at 450° F. It is stated that the pump has been specifically designed for those services where the temperatures or pressure may be very high, where hot or cold liquids are handled near their boiling points, and continuity or operation is important. The design features lowest possible net positive suction head to prevent cavitation, and is suitable for use where suction pressure or vacuum is extremely high and stuffing box leakage is an expensive loss or is hazardous. Wide capacity range at high efficiency is claimed, and minimum maintenance cost.

CHECK THE CARD AT PAGE 229

5—Blowers

Bryant Heater Company, Industrial Division, 1020 London Road, Cleveland 10, Ohio, has designed a new line of light-weight blowers for constant pressure capacity over a wide range. The Hi-Flo blowers are built for ease of application and for mounting in conjunction with other units.

Any one of seven outlet positions may be chosen in a simple changeover scheme requiring only a wrench for adjustment. A flanged outlet connection does away with the need for pipe unions in the air line. An easy-to-level three-point mounting base additionally simplifies the application of the light-weight units. Although normally supplied for clockwise rotation, the entire unit may be easily reversed without special tools.

A specially designed hub arrangement has been incorporated in the blowers to permit the use of standard 3450 rpm motors with regular shaft extension.

Maintenance has also been minimized in the Hi-Flo design. No close clearances are involved, and the machines are readily opened for cleaning. Should impellers become damaged, they may be easily and economically replaced.

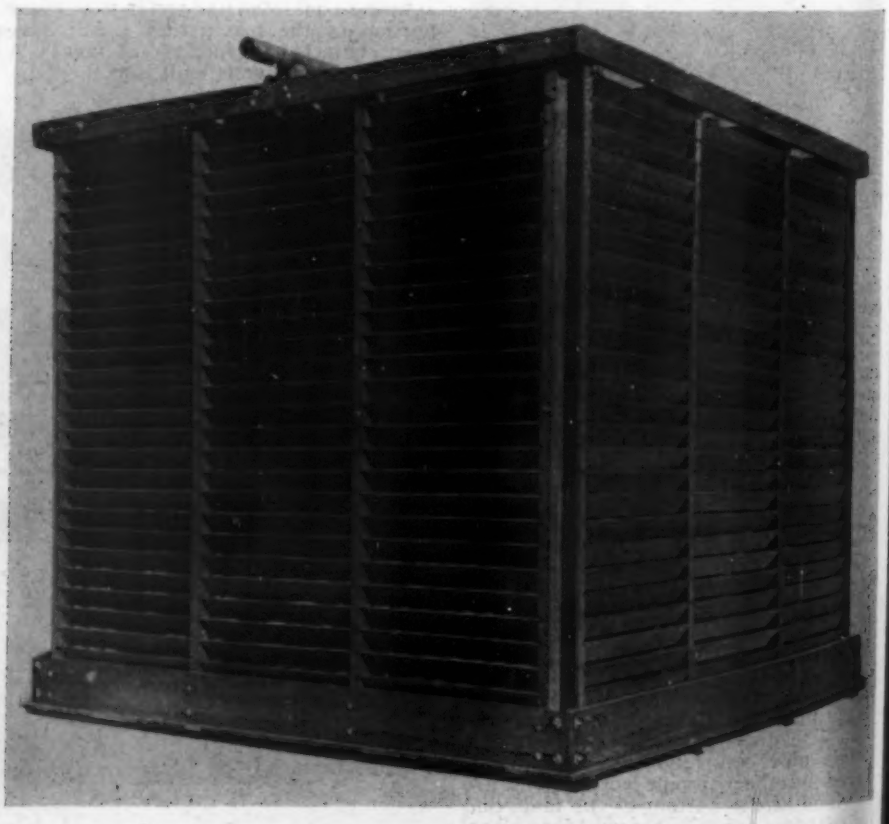
Bryant Blower

The blowers initially available in this series range from 2″ to 6″ in outlet pipe size, supplying 100 to 525 cfm in the 4 oz. pressure classification, and in 2″ and 3″ outlet sizes furnishing 125 cfm at 18 oz., and 275 cfm at 16 oz., respectively. Powering motors range from ⅓ to 2 hp for these machines, with power requirements in direct proportion to the actual amount of air used.

CHECK THE CARD AT PAGE 229

6—Cooling Tower

The Marley Company, Kansas City 15, Kansas, is offering a new design in natural draft cooling tower, Series 200, which may be adapted to several refining uses such as engine jacket cooling. It may be purchased in several sizes and



Marley Cooling Tower

added to as expansion requires. It can be used for either open or closed cooling systems. Capacity ranges from 65 to 1580 gpm.

The tower is prefabricated and shipped knocked down and with each member piece marked to assist in erection. Operation and maintenance instructions are furnished with each tower.

Standard bays are used in the design. Standard atmospheric sections may be installed at any time for closed cooling. Heavy select hardwood is used throughout with galvanized bolts and special hardware at critical points. It is designed for 100 mph wind resistance.

CHECK THE CARD AT PAGE 229

7—Welding Rod

Air Reduction Sales Company, 60 East 42nd Street, New York, recently announced the availability of a new welding rod, the Airco No. 23A. This rod is of a silicon-copper analysis while the previous rod offered for copper welding was of a phosphorus-deoxidized copper analysis. It is claimed, that, in addition to having superior flowing characteristics, this new silicon-copper welding rod will provide stronger welds than the deoxidized copper analysis, and an excellent color match on copper.

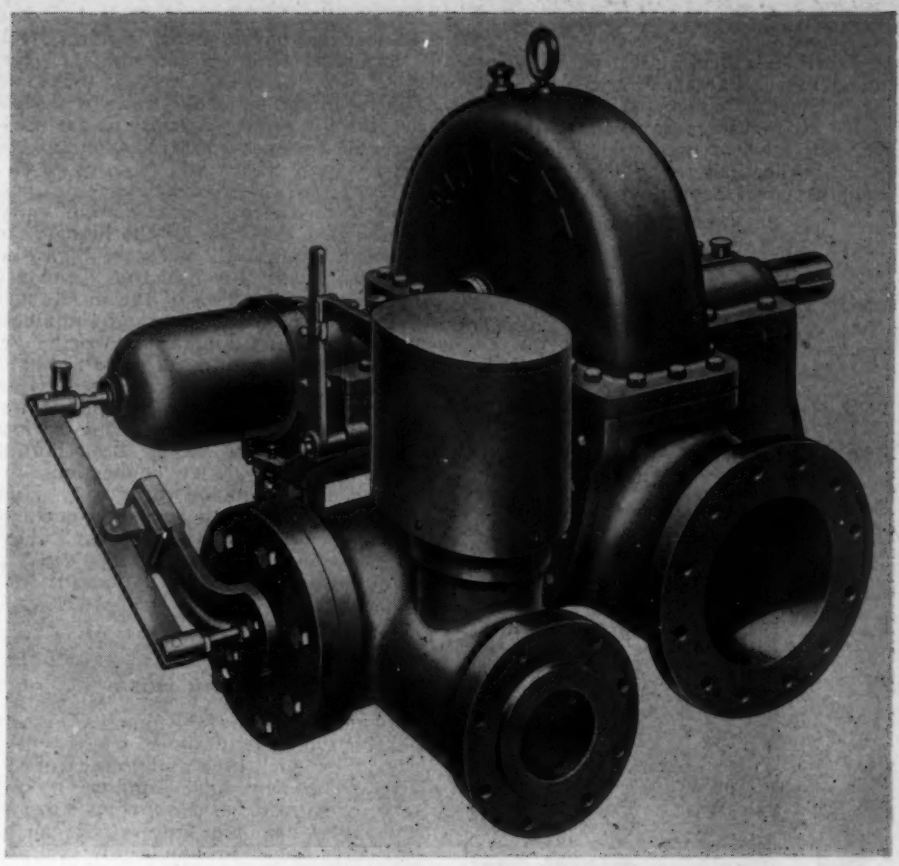
Based on manufacturer's tests, it is stated that the new Airco No. 23A welding rod is the equal of silver-copper rods for this class of work, and that cost is well below that of the silver bearing rod.

CHECK THE CARD AT PAGE 229

8—Turbine

Elliott Company, Jeannette, Pennsylvania, is announcing a new YR line of mechanical drive turbines. The new turbine incorporates capacities, up to 2000 hp, higher allowable steam pressures and temperatures, higher allowable back pressures, through 250 psig, higher operating speeds, through 6000 rpm, and in general greater flexibility.

Full advantage has been taken of new materials and latest construction techniques. The turbines have been made suitable for installation outdoors by sealing the bearings and completely enclosing the governing parts. Maintenance costs have been reduced by standardizing parts so that they can be used on two or more frames and by simplifying parts, such as main bearings, to reduce replacement costs to a minimum.



Elliott Mechanical Drive Turbine

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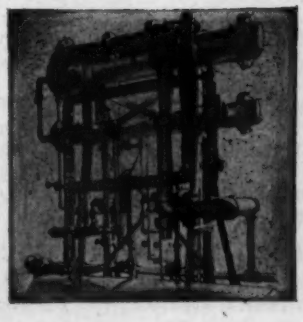
99.99% PERFECT VACUUM

This degree of vacuum referred to the average sea level barometer is maintained by the Croll-Reynolds five stage steam jet EVACTOR. If five stages sound complicated consider the fact that there are absolutely no moving parts. Each stage from a mechanical standpoint is as simple as the valve that turns it on. Numerous four stage units for maintaining industrial vacuum down to 0.2 mm. and less, and many thousands of one, two and three stage units are maintaining vacuum for intermediate industrial requirements on practically all types of processing equipment.



An engineering staff of many years experience has specialized on this type of equipment and has contributed toward the development of several vacuum processes which have revolutionized certain manufacturing operations, improved certain commercial products, and assisted in the development of new products.

Water jet Ejectors marketed under our trade name HYDRO-VACTORS and vacuum cooling units well known to industry as Croll-Reynolds CHILL-VACTORS round out this line of specialized equipment.

CROLL-REYNOLDS CO.

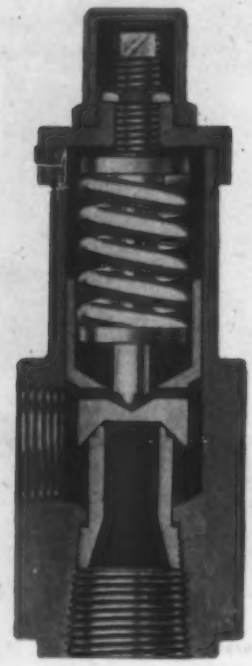
17 JOHN STREET, NEW YORK 7, N. Y.

CHILL VACTORS STEAM JET EVACTORS CONDENSING EQUIPMENT

CROLL-REYNOLDS

9—Safety Relief Valve

Farris Engineering Corp., 484 Commercial Ave., Palisades Park, New Jersey, has introduced a new and simplified relief valve for pressures up to 10,000 psi. The valve is fabricated completely from bar stock, either bronze, cold rolled steel or stainless steel depending on the service for which it is intended. In either case the disc and nozzle are of stainless steel.



Relief Valve

Available with or without test gear, in 3 body sizes—½-inch, ¾-inch and 1-inch—interchangeable nozzle inserts provide for proper capacity at set pressures in 3 ranges—2000, 5000 and 10,000 psi for each size.

Exceptionally high flow efficiency, with a coefficient approximating unity, is obtained by virtue of the high lift of the disc brought about by the high kinetic energy of the discharge developed by the venturi action of the nozzle.

By sound basic design and simplification of construction, a noteworthy reduction in the number of parts normally required in a valve for such services, has been achieved. The top-guided disc piston with its 2-point bearing surface is completely free acting. Both bottom inlet and side outlet connections are tapped directly in the valve body. High carbon steel loading spring is enclosed and protected. Nozzle seat is well above the drain line, hence remains dry and is not subject to accumulations of scale or sediment.

CHECK THE CARD AT PAGE 229

10—Fire Fighting Hose

Goodyear Tire & Rubber Company, Akron, Ohio, has designed a new type of steam for such uses as fighting refinery fires. The new hose employs a spun glass yarn as a basic component to gain maximum heat resistance. It is capable of carrying 200 pounds of saturated steam at 388° F. for more than 300 hours under continuous flexing.

CHECK THE CARD AT PAGE 229

Safety Goggles

11—Spectacle Type Goggle

A new spectacle-type safety goggle, said to meet the highest of safety and optical standards, is announced by American Optical Company, Southbridge, Mass. Offering maximum protection, this goggle with its acetate frame provides a more exact fit, increased comfort and better appearance. The goggle is available with either cable or skull temples and clear or armor-plate lenses.

CHECK THE CARD AT PAGE 229

BRASS
BOLTS-NUTS
in stock!

Your top source of brass fastenings today is Harper . . . the organization that specializes in manufacturing and stocking brass bolts, nuts, screws, washers, rivets and accessories . . . as well as other non-ferrous and stainless steel fastenings. Immediate shipment from almost all of 5,200 stock items. Write for summarized catalog of strong, durable fastenings that resist rust and corrosion.

THE H. M. HARPER COMPANY
2663 Fletcher St. • Chicago 18, Ill.
Branches or Representatives in principal cities

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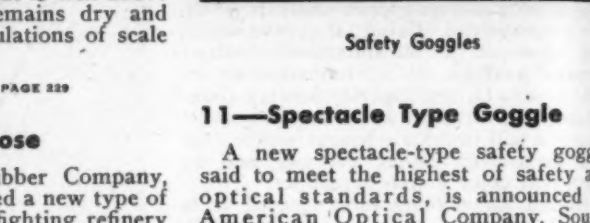
EVERLASTING FASTENINGS

Hi-Pressure Gage Glasses
Round, Tubular and Flat Type



RUBBER GAGE GLASS GASKETS
Series 750 . . . All Sizes

Fig. 21 Fig. 22

Other Ernst Specialties
are given in Catalog No. 48 P

GAGE GLASS ILLUMINATORS
NEW PLASTIC GUARDS
SIGHT FLOW INDICATORS
SPLIT-GLAND WATER GAGE
STEEL GAGE VALVES
FLAT GLASS INSERTS
ALL IRON GAGES
HIGH & LOW ALARM COLUMNS
MICA SHIELDS AND GASKETS
AND OTHER HELPFUL TIPS ON BOILER ROOM SAFETY

Fig. 12

Inclined for Better Visibility
Standard Type—Offset Adjustable Inclined Gage Fittings

Fig. 47

Fig. 13
Leakless Super Try Cocks, Bronze and Forged Steel Construction

Send for Catalog 48P

Ernst WATER COLUMN & GAGE CO.
LIVINGSTON, N. J. LIVINGSTON 6-1400

12—High Pressure Valve

Fisher Governor Company, Marshalltown, Iowa, has compiled a new bulletin, R-1, which describes its cast steel 3000 pound and 6000 pound angle and globe pattern single seated valve bodies with venturi type seat rings, having gasket-sealed construction and heavy guided micro-form pump type inner valves.

CHECK THE CARD AT PAGE 229

13—Tank Car Ladings

American Car and Foundry Company, 30 Church Street, New York 8, has issued a booklet titled "Tank Car Classifications for Ladings," in which are tabulated classes of tank cars authorized for shipping Interstate Commerce Commission regulatory and certain non-regulatory commodities.

CHECK THE CARD AT PAGE 229

14—Rotary Pumps

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has available a new Bulletin W-484-B1, describing its general service rotary pumps.

CHECK THE CARD AT PAGE 229

15—Expansion Joint

American District Steam Company, North Tonawanda, New York, has available an 8-page illustrated bulletin No. 35-30D, concerning its internally guided expansion joint for steam, water and oil lines. It gives details as to construction, dimensions and list prices in single and double joints for working pressures up to 300 pounds.

CHECK THE CARD AT PAGE 229

16—Lubricated Plug Valve

The Duriron Company, Inc., Dayton 1, Ohio, has released a 2-page bulletin, No. 617, which gives complete details on its corrosion resistant top lubricated plug valve. A cut-away section shows which parts are made of the corrosive resistant material and the principle of operation is explained in the text. The bulletin includes a list of operating features of this type of valve.

CHECK THE CARD AT PAGE 229

17—Tube Expander

The Gustav Wiedeke Company, 1833 Richard Street, Dayton 1, Ohio, has revised its bulletin No. 65-B, which announces its new 1500 Ideal Tube Expander, which is designed with a new short frame for use in small headers or other close quarters where tube holes are not in direct line with hand holes.

CHECK THE CARD AT PAGE 229

18—Reference Chart

The Ohio Injector Company, Wadsworth, Ohio, has available a 20-page valve cross reference chart, which contains a complete listing of its valve numbers in order and with descriptions.

CHECK THE CARD AT PAGE 229

19—Floor Boxes

Russell & Stoll Company, 125 Barclay Street, New York 7, has issued a 12-page Catalog FB147-51, "Floor Boxes and Accessories." New items are included in this catalog which describes all types of watertight floor boxes and receptacles, combination floor extension sets, floor outlet type receptacles, heavy-duty floor receptacles, plugs, and associated receptacles.

CHECK THE CARD AT PAGE 229

20—Engine Safety Controls

Viking Instruments, Inc., East Haddam, Connecticut, has issued Catalog No. 646, which covers protective equipment for internal-combustion engines.

CHECK THE CARD AT PAGE 229

21—Motors

Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14, Missouri, has issued an eight-page bulletin, MU-25A, which describes and illustrates the advantages of totally-enclosed motors, of both fan-cooled and non-ventilating type, for application to machine tools.

CHECK THE CARD AT PAGE 229

22—Cycle Controller

The Bristol Company, Waterbury, Connecticut, has devoted bulletin C305 to its new line of C500 impulse sequence time cycle controllers. It gives detailed information as to the application of the equipment in process operations. It is illustrated with line drawings to show principle of operation and method of use in typical plant uses.

HOW

STOKES

CAN SERVE

YOU

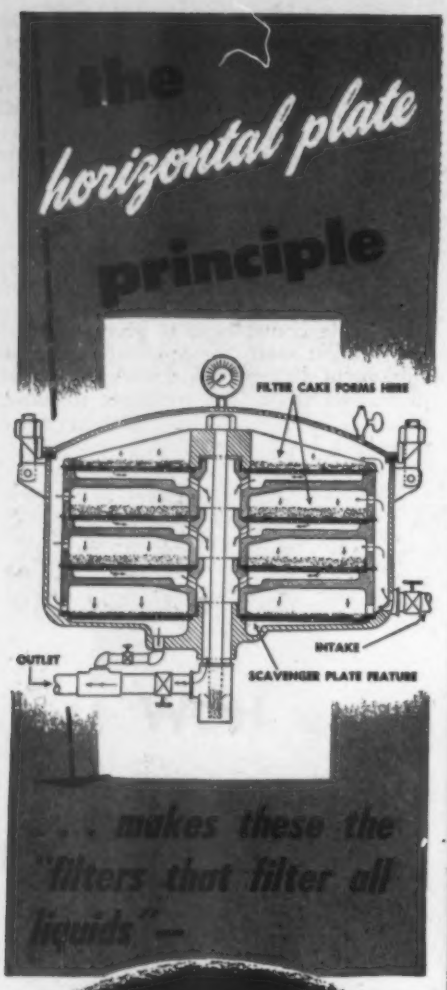
R. A. STOKES, Inc. can help you hold plant maintenance costs on Refineries or Terminals to the minimum by giving you top quality Industrial Painting Service. Good tools, know how workmen, plus long experience, are a part of each operation at no added cost.

R. A. STOKES, Inc.

Industrial Painters

653 Nixon Building

CORPUS CHRISTI • TEXAS


the horizontal plate principle
FILTER CAKE FORMS HERE
OUTLET
INTAKE
SCAVENGER PLATE FEATURE
. . . makes these the "filters that filter all liquids"—

SPARKLER
Horizontal Plate
FILTERS

. . . and here's the story:

- Sparkler Horizontal Plate Filters handle any liquid from heavy varnishes to light alcohols, including products such as acids, oils, beverages, milk, pharmaceuticals, plating solutions, water, etc.
- Equally efficient performance on intermittent or continuous operation, under a wide range of temperature, pressure and viscosity conditions.
- Equally effective whether removing carbons and contact clays or clarifying and polishing with filter aids.
- Patented Scavenger Plate permits complete batch filtration. (It's virtually an auxiliary filter with an independent control valve.)
- Unexcelled filter cake stability—no slipping or breaking.

. . . why?

Because filter media are supported on a horizontal plane and filter aids floated into position uniformly, filtration takes place uniformly over entire filtering areas. Flow through filter is always *with* gravity.
Sparkler Filtration Is *Engineered* Filtration—we invite correspondence on your problem. You will receive the advice of filtration scientists with a quarter of a century of experience in a specific field.

SPARKLER MANUFACTURING CO.
MUNDELEIN, ILLINOIS

About EQUIPMENT—SERVICE Suppliers

Vice Presidents Named By Babcock & Wilcox

Anthony M. Kohler and Alan E. Phinn have been named vice presidents of The Babcock & Wilcox Company. Kohler has been general manager of the refractories division since 1930 while Phinn has been in charge of accounting since he joined the company in 1927.

Kohler joined the company in 1913 as production engineer and in 1920, when the company started manufacturing refractories, he was placed in charge of that development work. As the Refractories Division continued to expand, he was responsible for the development and construction of the Augusta, (Georgia) Works.

Kohler who was educated in England

Kohler

Phinn

where he received his mechanical engineering degree from the City and Guilds College in London, is a member of ASME, The Society of Naval Architects and Marine Engineers, The American Ceramic Society and is active in the Refractories Institute.

Phinn received his training in Canada and is a member of the Institute of Chartered Accountants of Ontario, Canada, and of the Comptrollers Institute of America.

Allis-Chalmers Officials Re-elected

Walter Geist was elected for his sixth term as president of the Allis-Chalmers Manufacturing Company May 8 as all directors and officers of the firm were re-elected at the annual meeting of the stockholders and the board of directors.

The directors elected by the stockholders were W. C. Buchanan, Geist, Walter Kasten, Alfred J. Kieckhefer and Louis Quarles, all of Milwaukee; Arthur W. Butler, New York, N. Y.; John H. Collier and James D. Cunningham, Chicago, Ill.; Ernst Nahler, Neenah, Wisc., and Leigh Willard, Cleveland, Ohio.

Franklin Supply Officers

In the annual shareholders meeting of Franklin Supply Company, held in Chicago May 16, directors and company officers were elected for the ensuing year as follows: Jene Harper, president; Stanley Martin, vice president; Albert J. Mitchell, treasurer; and Jean Harper, secretary.

Pennsalt Names Ott Assistant Manager of Market Research

Edwin M. Ott, chemical engineer in the market research department of Pennsylvania Salt Manufacturing Company, has been named assistant to George T. Collins, manager of the department.

Ott came to the company's market research department from Gulf Research & Development Company in 1940. He entered the Army in 1942, and after four years in chemical warfare service was discharged as captain, and returned to the company. He is a graduate of Drexel Institute of Technology with a degree of bachelor of science in chemical engineering, and is a member of American Chemical Society and Chemical Market Research Association.

Tube-Turns Chicago Officials Moved to Larger Quarters

Chicago offices of Tube Turns, Inc., Louisville, have been moved to 904 Fairbanks-Morse Building, 600 South Michigan Avenue. The new and larger offices will be the headquarters for George C. Anderson, district manager of welding fittings division, Donald A. MacNeil, district manager of forging divisions, and their staffs.

Carlson Heads Unit

Howard R. Carlson has been selected to head up the recently formed petroleum field service engineering division of Marman Products Company, Inc., 940 West Redondo Boulevard, Inglewood, California.

Carlson

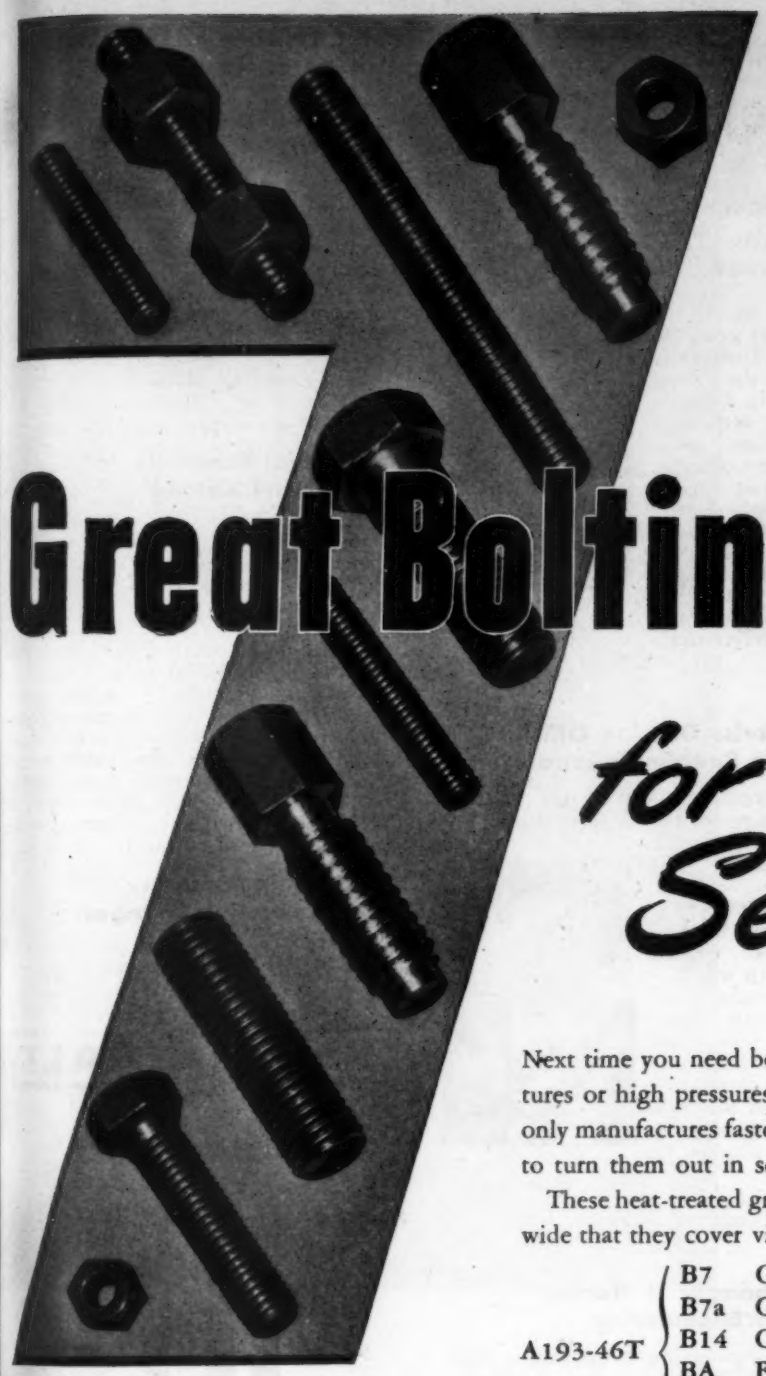
This section will have a two-fold purpose. 1) to study the clamping problems of the petroleum industry in order to engineer, develop, and present new and more efficient clamping devices; and 2) to extend customer service in working out field clamping problems and in meeting emergency delivery requirements.

Carlson is a graduate of Oregon State University, began his career as an industrial engineer. A lieutenant in the Navy, he has been with Marman since V-J day.

Ladish Co. Announces West Coast Manager

Ladish Co. of Cudahy, Wisconsin has announced appointment of H. L. Pehrson as manager of West Coast Sales of Ladish forged and seamless welding pipe fittings with offices at 714 West Olympic Boulevard, Los Angeles 15, Calif.

Pehrson, well known in western piping circles, has been closely associated with the valve and piping business for the



Great Bolting Grades *for Refinery Service*

Next time you need bolts, studs, or set screws for service at high temperatures or high pressures, get in touch with Bethlehem. For Bethlehem not only manufactures fastenings for use under these conditions, but is prepared to turn them out in seven grades of steel.

These heat-treated grades are listed below. Their range of properties is so wide that they cover virtually every high-temperature bolting requirement.

A193-46T	B7	CHROMIUM-MOLYBDENUM
	B7a	CHROMIUM-HIGH MOLYBDENUM
	B14	CHROMIUM-MOLYBDENUM-VANADIUM
	BA	FORMERLY SPECIFICATION A96, CLASS A
	BB	FORMERLY SPECIFICATION A96, CLASS B
	BC	FORMERLY SPECIFICATION A96, CLASS C
A261-44T	BO	CARBON STEEL

Bethlehem has a fully-equipped fastenings plant at Lebanon, Pa., with an engineering staff that is thoroughly familiar with the manufacture of steel bolting for severe operating conditions. If you have a bolting problem involving high temperatures or high pressures, talk it over with a Bethlehem fastenings engineer. For complete information, get in touch with the nearest Bethlehem district office, or write direct to us at Bethlehem, Pa.

BETHLEHEM STEEL

(One of a series of advertisements describing the steels used by Bethlehem in the manufacture of high-temperature fastenings.)

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

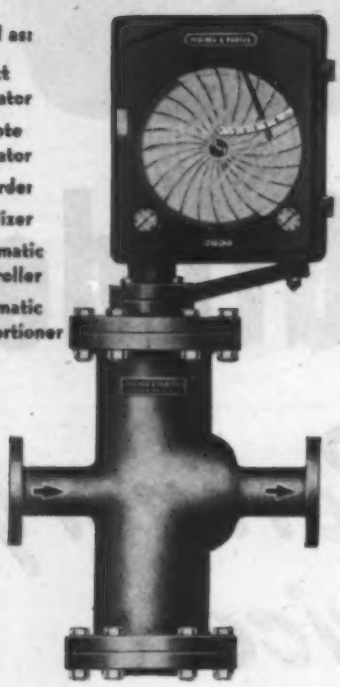
Bethlehem supplies every type of Fastening

ARMORED FLOWRATOR

FOR TOUGH FLOW MEASUREMENT PROBLEMS

Supplied as:

1. Direct Indicator
2. Remote Indicator
3. Recorder
4. Totalizer
5. Automatic Controller
6. Automatic Proportioner



The F. & P. FLOWRATOR instrument (formerly called Rotameter) is now available for any pressure or temperature and for large flow rates in the new armored "valve-body" design having no glass parts exposed to operating pressure differential.

It uses magnetic, electric or electronic transmission systems. With the electronic system it can record and control flows down to fractions of a cc per minute, is continuously self-balancing, travels full scale in less than 3 seconds, uses no slide wire.

The automatic proportioner arrangement, due to its linear chart scale, eliminates the range restrictions and coordinates difficulties inherent in variable head (orifice) type proportioning installations.

PRICES NOW REDUCED TO LESS THAN WAR-TIME PRICES

For detailed information send for:

Catalog 40—Armored meter

Catalog 50—Electric and magnetic remote instrument

Catalog 52—Electronic recording instrument

FLOWRATOR
TRADEMARK
FISCHER & PORTER CO.
DEPT. 7R-1C HATBORO, PENNA.

past 16 years with the Reading Pratt and Cady Division of American Chain and Cable Company. For the last six years he has been Southern California representative on petroleum and industrial sales.

Elliott Promotes Wilson

F. Q. Wilson, Jr., has been appointed Elliott Company Cincinnati district manager.

Wilson

Wilson, an electrical engineer graduate of Kansas University came with the Elliott Company in 1938.

He was sent as a field engineer to the Kansas City office in 1940, moved on to the Tulsa sub-district office in 1942 and became sub-office manager in 1945. The following year, 1946 he was named a full district office manager.

Wire Fabrics Division Official Named in Roebling's Expansion

J. F. Berger has been named assistant sales manager of the Woven Wire Fabrics Division of John A. Roebling's Sons Company.

Berger

His appointment is coincident with a program of expansion in both machinery and products for the Woven Wire Fabrics Division. This expansion is part of the company's program of modernization and enlargement of production facilities.

Berger has been with the company 37 years.

Sales Manager Is Named By Farris Engineering

Farris Engineering Corporation, Palisades Park, N. J., has announced appointment of Paul Robinet as sales manager.

Robinet

Robinet, a mechanical engineer graduate of the University of Southern California, has been for eight years the West Coast sales engineer, particularly in the oil, steam and martime industries, for Consolidate - Ashcroft - Hancock division of Maxwell, Manning and Moore, Inc. Two years ago, he was made sales engineer in their New York office, which position he has recently resigned.

With Farris Corporation, he will be in charge of formulating sales and promotional policies throughout the United States for this organization.

Brown Instrument Expands Facilities in Houston

Rapid growth of industry throughout the Southwest has resulted in expansion of the Houston office of Minneapolis-Honeywell Regulator Company, of which Brown Instrument Company is a division, R. L. Mallory, regional manager, has announced.

Increased demand for heating, air conditioning, and industrial controls throughout the area caused the company to move to a new location at 2123 Travis. The Houston office serves as regional headquarters for the Gulf coast of Texas, Louisiana, part of Mississippi, northern Texas, southern Arkansas, Oklahoma, and southern Kansas.

Commercial Quantities of Methyl Ethyl Ketone

Celanese Chemical Corporation has announced that it is now producing tank car quantities of methyl ethyl ketone, widely used solvent. In addition to outstanding solvent power, methyl ethyl ketone possesses a high boiling point and low vapor pressure, its unusual properties making it useful as an intermediate in the manufacture of organic chemicals and dyes. It is a colorless liquid, soluble in water, alcohol and ether and miscible with oils. Celanese methyl ethyl ketone, made synthetically from natural gas components, is said to be produced under rigid controls in order to maintain high standards of purity.

The Midvale Company Makes Executive Changes

Richard T. Nalle has been elected president of The Midvale Company, suc-

PENN SALT

Anhydrous

HF

Effective and practical alkylation catalyst for production of high octane motor fuels.

•

Also finding use as condensation reagent. Of increasing interest in polymerization, isomerization and acylation reactions.

•

Write for helpful booklet, "How to Handle Anhydrous Hydrofluoric Acid Safely."

•

PENNSYLVANIA SALT MANUFACTURING COMPANY
1000 WIDENER BUILDING, PHILADELPHIA 7, PA.
New York • Chicago • St. Louis • Pittsburgh
Cincinnati • Wyandotte • Tacoma • Portland, Ore

The dimension that "specs" don't cover

Your specifications may be as complete and perfect as it is humanly possible to make them.

But the one most important dimension of all can't be written into specifications—and that's the perfection exercised by the men who do the work.

All modern shops have access to good measuring devices. All shops have inspection systems. But results can vary greatly according to the ability of the men who use the instruments and do the inspecting.

One of the principal reasons for Kellogg's high reputation in the fabricated products field is the stability of its organization and the experience of its personnel. Among employees the average length of service is 5 years; layout men average 10 years; inspectors 13 years; the senior pipe bender is a veteran of 39 years experience.

It's the extra quality that these men put into a job that guarantees more than specifications call for—when you turn those "specs" over to Kellogg.

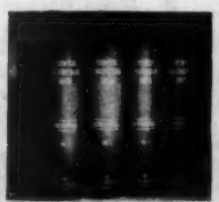
FABRICATED PRODUCTS DIVISION

THE M. W. KELLOGG COMPANY

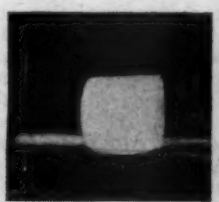
NEW YORK • JERSEY CITY • BUFFALO • LOS ANGELES
TULSA • HOUSTON • TORONTO • LONDON • PARIS

VESSELS • EXCHANGERS • CONDENSERS • HIGH PRESSURE AND HIGH TEMPERATURE POWER PIPING PROCESS PIPING • FORGED AND WELDED FITTINGS . . . IN ALL STEELS, ALLOYS OR SPECIAL COMBINATIONS

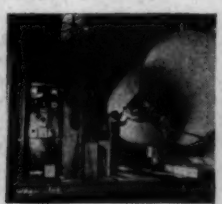
Metallurgical Research conducted continually by recognized specialists who have made major contributions in this field.



Unique Technical Backing of an extensive organization with an international reputation in both process and fabrication engineering.



Complete Facilities for the fabrication of steel products from simple forgings to the most intricate 120 foot towers.



Quality Control embracing the constant application of the most advanced inspection methods, both visual and non-destructive.

On-Time Delivery made possible by a flexible planning group authorized to re-route work to meet promised dates.

Top Welding Performance assured by specially designed equipment and exclusive employment of master operators.

You Can Save Money On These Two Cleaning Jobs

Put these money-saving Oakite maintenance techniques to work for you. You'll find that they make possible significant savings in time, effort and money.

DE-SLUDGING DIESEL FILTERS: To restore sludge-clogged filter screens to normal efficiency, use a specially designed Oakite cleaning compound. When you see how quick is the removal of crude oil residues and other obstinate deposits, you'll agree there's nothing like Oakite de-sludging for cutting costs, reducing equipment downtime, prolonging filter screen life.

DE-SCALING DIESEL FILTERS: Specialized Oakite inhibited acid-type descalant, Oakite Compound No. 32, is widely used for dissolving lime scale and rust deposits that clog Diesel cooling systems. Proper heat transfer and peak operating efficiency are maintained. Rated engine power is developed and fuel consumption held at a minimum.

To obtain further details on these and other specialized Oakite cleaning methods and materials, write us. Information will be promptly mailed on request.

OAKITE PRODUCTS, INC.
380 Thames Street, NEW YORK 6, N. Y.
Technical Representatives in Principal Cities of U. S. & Canada

OAKITE

Specialized Industrial Cleaning
MATERIALS • METHODS • SERVICE

ceeding Francis Bradley who has been elected chairman of the board of directors after forty-five years service with the company, according to an announcement made by Henry H. Ziesing, vice president in charge of sales.

Ohio Representatives for Mixing Equipment Listed

White Industrial Sales & Equipment Company, with offices in Akron and Cleveland will handle Mixing Equipment Company's account in the state of Ohio.

In the Akron office H. H. Baker, Jr., chemical engineer, graduate of the University of Louisville and formerly with Firestone Tire and Rubber Company, will be the customer contact engineer while O. H. Heinicke and H. H. Baker, Jr., will serve customers in the Cleveland area.

Main offices of the White Organization, headed by E. V. White, president, are in Cincinnati which office serves the Southern part of Ohio, H. B. Schroder Jr., and K. C. Matthews, being that office's customer contact engineers.

Manager of Goodyear Mechanical Goods Division Dies

Woodburn C. Winings, 54, manager of Goodyear Tire & Rubber Co.'s mechanical goods division, Akron, Ohio, and associated with the firm 32 years, died May 10 in a Brunswick, Ga., hospital after a short illness.

A native of Indianapolis, Winings attended Wabash College and joined Goodyear in 1915 as a salesman. After holding sales posts in Indianapolis and Chicago, he transferred to Akron in 1928 as assistant manager of the company's mechanical goods division, and became manager in 1930.

During World War I, Winings served overseas as a navy balloon pilot.

Jenkins Bros. Elects New Officials

Alfred J. Yardley has been elected president of Jenkins Bros., succeeding his father, Farnham Yardley, who becomes chairman of the board after serving as president for 30 years. C. C. Chamberlain, general sales manager, and James L. Dunn, vice president in charge of industrial relations, were added to the company's board of directors.

Chamberlain has been with the company since graduating from Hamilton College in 1929, starting as an assistant in the advertising department, and has been general sales manager since 1942.

Dunn joined the organization in 1913 and was assistant plant manager when he was appointed to the public relations post in 1944.

American Arch Company Names Hazen Manager

Frank D. Hazen, who has been general sales manager of the industrial department of American Arch Company, Inc., New York locomotive equipment firm, has been appointed vice president and general manager of the department, with Pittsburgh headquarters.

Hazen, associated with American Arch for 22 years, was engaged for eight years prior to joining the company in construction work for Inland Steel Company and Illinois Steel Company. During World War I he served as an ensign in the U. S. Navy.

He is the author of a number of tech-

Sales Engineers

Men with engineering degrees, under 30 who want sales engineering work, please write us. We have placed several lately. Very confidential. No charge to employees. Oil Industry Employment Service, P. O. Box 2603, Tulsa, Okla.

RUST-OLEUM

POSITIVELY PREVENTS RUST

Longer life for tanks, buildings, structural steel, machinery, pipes, stairways, loading racks, fences and every metal surface.

(See page 968—Refinery Catalog)

RUST-OLEUM
CORPORATION
EVANSTON, ILLINOIS
TEXAS BRANCH
1935 Commerce St., Dallas, Texas

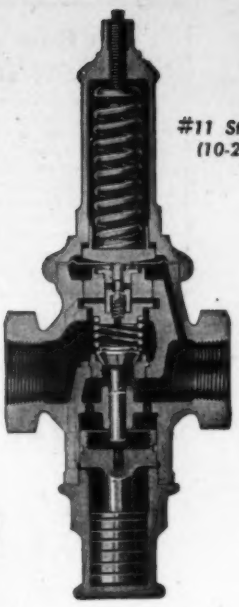
Multi-Metal

Wire Cloth
Filter Cloth
All Meshes
All Metals

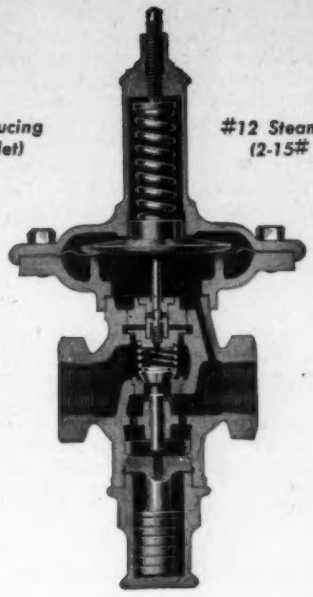
FABRICATED WIRE CLOTH

For more than 34 years Multi-Metal has designed and fabricated an infinite variety of filter units which involve the use of wire cloth. Multi-Metal stresses its technical facility. In addition to our fabrication plant, we carry a wide variety of wire cloth which is available by the roll and cut piece. Write for our new catalog and free wire cloth samples.

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.



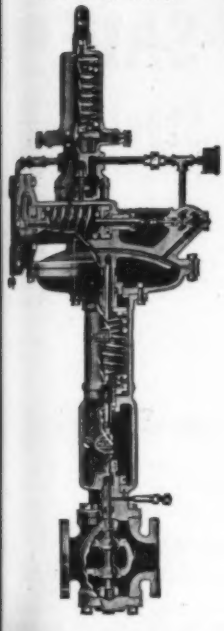
#11 Steam Reducing
(10-225# Outlet)



#12 Steam Reducing
(2-15# Outlet)

#35 Reducing
#36 Back Press.

#27 Reducing
#47 Back Press.



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#2500-38 (or 37)
Reducing or B.P.

#33 Reducing

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That is the method used for years in a Washington, D. C., filtration plant. At 165 lbs. working pressure, with flue gases entering at 450° F., not one joint sealed with Smooth-On No. 1 has ever developed leaks, they reported.

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FREE SMOOTH-ON REPAIR HANDBOOK

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6-47.....

Do it with
SMOOTH-ON
Iron Cement of 1000 Uses

nical papers and has made many contributions to the development of the furnace industry, including the design of the first suspended arch that could be insulated without burying and overheating the metallic supports. He is a member of ASME.

Byler Now Manager Of Peabody Advertising

Peabody Engineering Corporation has appointed W. L. Byler advertising manager.

For the past three years he has been with Peabody Engineering Corporation in engineering and production work, where he also functioned as liaison man between phases of production and advertising.

Prior to his association with Peabody, Byler was a district sales representative and trained distribution salesmen to handle power transmission equipment. Before that he was a safety engineer.

Wilson Promoted in Monsanto Staff

Ivan V. Wilson has been appointed assistant director of research for the Monsanto Chemical Company's Merrimac Division.

Wilson, who was manager of the coating sales development department prior to assumption of his present duties, will be in charge of all research and application work connected with the development of new and improved types of coatings. he will be responsible for maintaining close liaison with the division's sales department on such new coatings and will coordinate the activities of sales and production with research.

Wilson came to Monsanto in 1927 and since then has largely been connected with the Sales and Development Departments of the Merrimac Division. He is a native of Willow Springs, Kansas, and a graduate of Kansas State College with a B.S. in Industrial Chemistry in 1924.

Promotions Calco Chemical Involve Klipstein, Atkins

Appointment of Kenneth H. Klipstein as an assistant general manager in charge of the development department and V. E. Atkins as manager of manufacturing has been announced by Calco Chemical Division, American Cyanamid Company.

Ames B. Hettrick, formerly an assistant manager of the pigment department, has been named assistant manager of manufacturing, and L. M. Phelps will assume the post of plant production manager, Bound Brook Plant, formerly held by Atkins. F. W. Zipf was named assistant to the manager of production.

K. H. Klipstein prior to his new appointment was director of new products development. He is a graduate of Princeton University where he obtained his A.B. degree in 1921 in economics and an M.A. degree in chemistry in 1924. He joined the family firm of E. C. Klipstein & Sons, South Charleston, W. Va., manufacturers of dyes and chemicals, which was later purchased by Calco in 1933. Coming to the Calco organization, Klipstein has since been engaged with all phases of product development work.

Atkins came to Calco in 1936 as an assistant divisional manager. Prior to joining the Calco organization, he had been a vice president and factory manager of the Seiberling Rubber Company.

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Well known company requires man for refinery inspection work. Prefer one with experience, but will train if familiar with general refinery equipment and processes. High School education or better. Must be capable of preparing intelligently written reports and presenting inspection results to Refinery Management. Car required. Must travel considerably. Write fully in confidence to Box 41-R, c/o Petroleum Refiner, Houston, Texas.

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(Specification ASTM A-106 — Grade B)

Total Feet Available	O.D.	Average Wall	Price per 100 Feet
915	5 9/16"	.950"	$300.00
2585	5 9/16"	.789"	258.00
2475	6 5/8"	.996"	384.00
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780	10 3/4"	1.443"	966.00

Average Lengths Available

Item #1—18 to 24 ft. Item #3—18 to 22 ft.
Item #2—17 to 24 ft. Item #4—13 to 24 ft.
Item #5—20 to 24 ft.

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½% 10 Days—Net 30
F.O.B. Cudahy, Wis.
$25.00 charge on lots of less than 250 feet on an individual item.
All offerings subject to prior sale.

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